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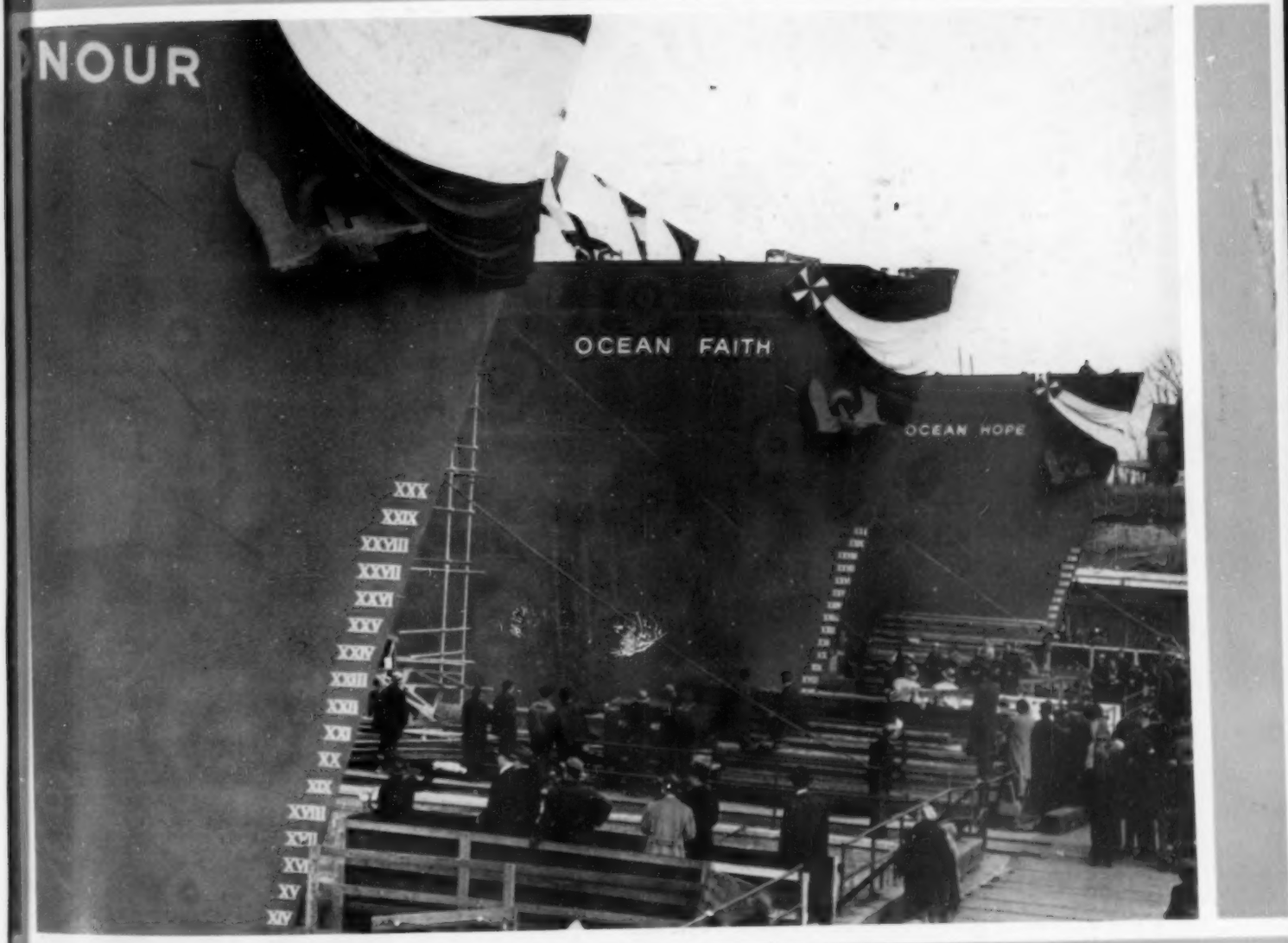

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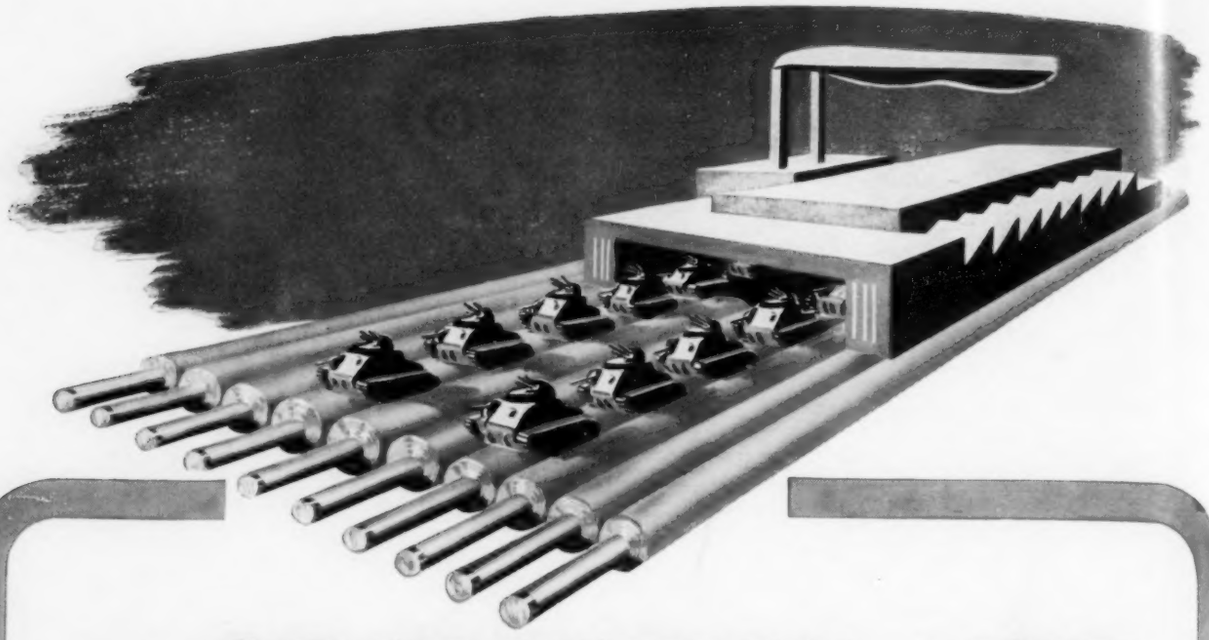

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Welding Fumes from Arc Welding*

By Gordon C. Harrold, Ph.D.†

I. Introduction

IN FACING the actuality of industrial hygienic shortcomings with regard to the exposures connected with arc welding, several things contribute to the obvious complexity of the situation. First, the quantitative determination of some welding gases, such as the several nitrogen oxides and ozone, is far more difficult than for many other substances. Second, the coating materials applied to welding rods are so diversified and so rapidly changed as to baffle almost any attempt to keep abreast of developments. Third, alloyed steels, such as nickel-chrome steel, or metals that have been coated, such as in galvanizing, are introducing new difficulties in connection with welding operations. As a result, the attending industrial hygienic situations are far from simple.

In general, the potential sources of injury from arc welding other than from trauma and thermal effects seemingly may be grouped in the following categories:

Oxygen deficiency.
Carbon monoxide.
Nitrous gases.
Ozone.
Metal fume from alloyed steel.
Metal fume from the metal electrodes.
Silica from welding rod coatings.
Harmful substances other than silica in rod coatings.
Injurious substances coated on to the metal being welded.
Radiations.
Possibly other gases such as cyanides theoretically produced in the electric arc.

From the fairly extensive first-hand experimental work and medical department experience with several hundred welders, we have reached a number of conclusions. These conclusions are developed first in regard to welding with bare rods, then coated rods and their by-products.

II. Bare Rod Welding

Two hundred and fifty animals (rabbits and albino rats), including 87 controls, were exposed in five major series of experiments, together with numerous casual and preliminary experiments, to the products of arc welding with bare, washed iron electrodes distributed over a period of 20 months. These animal exposures were attended by approximately 2400 analytical determinations for gases and fumes, embracing a minimum of 4 samples per hour during the daily welding cycle. The results of these animal exposures and accompanying analytical determinations lead to the following conclusions:

1. The quantity of "nitrous gases" (reported as nitrogen dioxide, NO_2) increased with every increase in voltage across the arc as utilized in welding. However, this statement must be considered in relation to the fact that with increased voltage the number of rods burnable per unit of time likewise increases.

2. The general average concentration of nitrogen dioxide (NO_2) in parts per million for increasing voltages across the arc were 29 p.p.m. at 27 v., 33 p.p.m. at 31 v., 40 p.p.m. at 33 v. and 70 p.p.m. at 44 v., under the uniform conditions of air change established in these experiments.

3. At a fixed voltage and after the period of actual welding, the "nitrous gases" remaining in the gassing chamber diminished as shown for 44 v.: 95 p.p.m. after welding, 73 p.p.m. 4 min. after welding, 53 p.p.m. 10 min. after welding, 46 p.p.m. 16 min. after welding, at which time a new cycle of welding began.

4. The highest concentration of "nitrous gases" at any time averaged 97 p.p.m. for 10 samples with an extreme maximum for a single sample of 135, with a duplicate of 127.

5. Ozone (O_3) was found in amounts of from 10 to 32 p.p.m. within 1 in. of the arc, 1.5 to 9 p.p.m., 4 in. from the arc and from 0.2 to 1 p.p.m. in the center of the chamber, with only slight variations for different voltages, all samples being taken during the flaming of the arc.

6. As every welding day proceeded, after the first hour the concentrations for any given sampling period, such as 4 or 16 min. after the cessation of welding, remained substantially the same. During the first hour of welding, the concentrations increased.

7. Indicated, but not quantitatively determined, was the presence of nitric oxide (NO) in some unknown concentration along with the nitrogen dioxide (NO_2) in the "nitrous gas" mixture.

8. Determinations of "nitrous gases" through the measurement of nitrogen dioxide (NO_2) by means of the nitrite methods, which depend on the diazo reactions, unlike the nitrate methods, have not proved reliable in these arc-welding experiments.

9. Under the conditions of these investigations, distribution of the "nitrous gases" was substantially uniform throughout the gassing chamber. This statement does not apply to the distribution of ozone.

10. During animal exposures, percentages of oxygen and carbon dioxide were normal and there was detected no contamination by carbon monoxide, chlorine or other extraneous gases.

* Presented at the Fifth Annual Tri-State Welding Conference, Pittsburgh, Pa., April 24, 1942.
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11. The quantity of particulate iron present as a fume and arising from the iron arc ranged from 35 to 395 mg. per cubic meter of air.

12. The quantity of iron fume present varied irregularly and sometimes inversely with voltage increases across the arc. It diminished after the cessation of welding.

13. No constant correlation was established between the respective quantities of iron fume and "nitrous gases" within the atmosphere of the welding chamber.

14. The quantity of manganese present in the welding chamber atmosphere and derived from the burned welding rod varied from 0.2 to 3.3 mg. per cubic meter of air. The iron–manganese ratio in the air approximated the ratio in the rod. Slight differences were encountered with some voltage variations which were attributed to alterations in the settling rates of the two types of particles.

15. No product of this experimental arc welding, regardless of voltage or duration of exposure through weeks, induced gross changes in experimental animals characteristic of the action of "nitrous gases."

16. The total exposure periods for animals, respectively, for four experiments were: at 27 v., 228 hrs.; 33 v., 205 hr.; 44 v., 150 hr.; 31 v., 120 hr. For these various voltages, the corresponding high average concentrations, respectively, were 32 p.p.m. for 50 hr., 47 p. p. m. for 45 hr., 84 p.p.m. for 33 hr., and 42 p.p.m. for 26 hr.

17. From all experiments, computations have been made as to the total number of hours of exposure of animals at various concentration levels. Thus in one experiment, where the average concentration was 70 p.p.m., the exposure was for 125 hr., not including the first hour. However, in this experiment, exposure was to 84 p.p.m. for 33 hr. With the exception of a portion of the first hour of every welding day, no exposure was to quantities of nitrous gases lower than 46 p.p.m.

18. In all experiments, the survivors exceeded 90% of animals at the beginning of the experiment, not including those sacrificed within the experimental period or those dead from extraneous causes. In certain experiments, all animals survived save those selected for necropsy purposes.

19. When high atmospheric temperatures existed in the welding chamber, animals readily succumbed. The maintenance of such temperatures in the absence of any welding or welding gases led to high mortality from no other known cause than excess heat. When increasing temperatures without welding peaked at 106° F. in an experimental chamber, when the average laboratory temperature approximated 72° F., only 1 of 7 rabbits survived one $6^1/_2$-hr. exposure period. Ten rats, more resistant to heat, survived 2 days of exposure peaking for short periods at 106° F. and were then subjected to increasing temperatures, whereupon all rats except one died. The highest temperature attained was 112° F. for short periods only.

20. Autopsies were carried out on irregular numbers of animals during exposure periods, larger numbers immediately at the termination of the experiments and on others at irregular intervals after exposure. At all times, evidences of iron deposition were encountered as the sole constant manifestation of abnormality. Transportation of this ferrous material to the periphery of the lung and the tracheobronchial glands was the rule. In no animals was there encounted any gross pulmonary edema or edema along any portion of the respiratory tract.

21. X-ray examinations made after the termination of final exposure periods both on the intact animal and on the extirpated lungs yielded no positive results.

22. Limited exposures for human beings embraced 3 hr. for two workers at an average concentration of 84 p.p.m. of nitrogen dioxide (NO_2), including a 40-min. period with exposure to 93 p.p.m. and a 5-min. period with an exposure of 103 p.p.m. No significant injury occurred.

23. In so far as indicated by these experiments, the threshold of harmful concentrations of "nitrous gases" lies above 70 p.p.m. for prolonged exposures.

24. In general, it has not proved possible to produce, under experimental conditions (which conditions exceed in severity those that attend usual industrial arc welding) sufficiently high concentrations of "nitros gases" characteristically to affect any of fairly large numbers of animals, exposed daily over several weeks.

The above case for bare rods was then extended to deal with the more complex situations involving coated rods.

III. Coatings on Rods

To meet these various purposes served by the rod coating, highly different substances enter into the coating mixture. Thus, to produce visible cloud about the arc, there may be present such ingredients as cotton lint, paper, powdered coke, etc. For the protecting slag layer immediately over the welding point, inorganic substances chiefly are used including borates, barium, calcium, aluminum and manganese compounds along with many others. In order to make up the deficiencies of the welding rod itself in relation to the metal to be welded, manganese, chromium, lead may enter into the coating itself. Lastly, it is necessary to bind these ingredients on to the rod, which calls for another class of materials, some of which in addition to being binders are gas generators. The number includes asphalt, resin, casein, ethyl silicate, sodium silicate, etc.

By way of practical objections to the use of heavily coated rods, welders have indicated that (1) it is difficult to observe the weld being made because of the overlying slag; (2) the cleaning of welds made with heavy coated rods is more difficult than the bare rod; (3) the increased visible clouds from the coated rods are disturbing and unwanted.

IV. Silica

Large numbers of coated rods contain silica or silicate. The prime use of silicates is as a binder for other coating materials. Organic silicates are used for this same purpose, but this use is limited. The high temperatures (circa 6500° F.) of the electric arc may convert the greater portion of combined silicon to silica. In the analysis of rod coating materials used in one of our series of experiments, the SiO_2 ranged between 17% and 20%. It has been computed that from the burning of a single 14-in., $^5/_{32}$-in. coated rod more than 150 mg. of fine particulate matter are introduced into the atmosphere. While this figure in itself is of little significance, it leads up to the statement that arc welding is or may be a dusty operation.

Dust from our welding showed 8% silica. Experiments at Harvard have shown that this type of silica is not all free silica. General conclusions were that dust from coated rods containing silica or silicate are unlikely to constitute any practical threat of silicosis.

V. Summary of Coated Metallic Rod Experiments

In addition to products created by the bare electrode were the new items, silica and titanium. No results suggest any injury from either of these agents.

Contrary to findings from bare rods, growth rate disturbances were encountered, chiefly in rats from which the case is unknown, though probably due to manganese.

Substantial quantities of methemoglobin were found in the blood of rats. In our previous animal work, no determinations were made for methemoglobin. Casual repetition of bare rod experiments established prompt methemoglobinemia in rats on the first day of exposure. A limited number of production welders were examined at a time when the NO_2 concentration in the work place was only 13 p.p.m. Methemoglobinemia was established. It is possible that, in the absence of other sources of methemoglobin, the presence of this entity in the blood of welders may indicate exposure to nitrous gases.

The quantity of nitrous gases produced by uniform electric power in case of the one coated rod investigated is distinctly less than in the case of bare rods at the same power.

Metallic fume in the gassing chamber is substantially increased when coated rods are employed. This is notably true of manganese fume in the coated rod used.

As in the case of bare rod experiments in which high quantities of nitrous gases were evolved, no evidence whatever accrued relative to pulmonary edema, severe respiratory tract inflammation or similar findings, traditionally associated with nitrous gas action.

Practical Applications and Implications

1. In our experience and from our appraisal of the literature, it does not appear that the health of arc welders as a class may be set apart as especially different from metal workers in general. Although occasional records of deaths appear associated with some aspect of welding as the cause, we have no evidence of any prevailing diseases characteristic of the work of the arc welder (radiation effects excepted).

2. In our experimental studies, with the rate of rod burning much higher than in practical welding, and with welding confined to a comparatively small chamber of 1000 cu. ft., with at times only one air change per hour, we have not been able to find any suggestion of oxygen deficiency.

3. The much discussed point of ozone formation in the welding arc has in our experience resolved itself as follows: Much ozone (10–32 p.p.m.) is produced immediately in the arc, but quickly is diminished (1–9 p.p.m.) a few inches (4 in.) away from the arc and in the center of the chamber the residual is not more than 1 p.p.m. of ozone. Although this exceeds the somewhat accepted threshold of injury of 0.4 p.p.m., no injury from this gas has been determined by us.

4. Numerous tests for carbon monoxide have been made under various conditions—always without any significant results.

5. Other things being equal, low voltage and amperage are desirable in arc welding, since it appears to be true that low voltage is conducive to the low formation of nitrous gases.

6. Our best efforts to produce from arc welding sufficiently high concentrations of nitrous gases to induce injury to animals after long exposure were not successful. Practical arc welding in open areas seldom leads to higher concentrations of nitrous gases than 20 p.p.m.

7. It is our observation that concentrations of nitrous gases near the widely accepted threshold of 39 p.p.m. are quite harmless to laboratory animals after prolonged exposure and further that double this quantity for prolonged exposures and treble this quantity for limited exposures likewise are without discernible ill effects on animals. Human beings exposed to such quantities as 84 to 103 p.p.m. of nitrous oxides for a few hours (3) suffered no ill consequences.

8. We possess some evidence that methemoglobin is formed both in laboratory animals and human beings exposed to welding gases, but the quantity of this methemoglobin appears to be without injurious properties and further there is theoretical evidence that comparatively low percentages of methemoglobin in the blood may under some circumstances serve beneficiently.

9. Limited experimental observation is unfavorable to any belief that silicosis may be brought about from silica dust exposures incident to arc welding.

10. The heavy iron content of the air incident to animal exposure in welding has not been shown, from clinical, X-ray and autopsy observations, to produce any injury beyond pigmentation.

11. Apparently coated rods are to be favored over bare rods in so far as the production of nitrous gases is concerned.

12. Finally, in appraising arc welding as an industrial procedure and with particular reference to hygienic problems we at least are convinced that some overemphasis in the past may have been placed on the significance of nitrous gases, carbon monoxide, ozone and iron fume. To the contrary, if there be practical hygienic problems related to arc welding (in addition to the obvious ultra-violet emanations), these may be expected in the little explored field of the constituents of coatings on rods, coatings on metals and special constituents of the metal welding rod or the metals being welded.

While the preceding material represents our laboratory's [1, 2, 3, 4] conclusions on this subject, I wish now to briefly review the problem of metal arc welding in the light of the experimental work performed within the last 4 yrs. Extensive work has been done by Drinker[5, 6] and his co-workers at Harvard. Tollman, MacQuiddy and LaTowsky and others at Nebraska,[7, 8] Britton and Walsh[9] at Northwestern and Von Haam[10] at Ohio State. While the Nebraska work was done with the carbon arc and carbon rods, all the other groups worked with the metallic rods. Except in minor details it is believed that their work is in full agreement with our own. Von Haam worked with three coated rods and produced much higher concentrations of fumes than will be found in practice except in small tanks. His conclusions were essentially to the effect that the one rod with high percentages of calcium fluoride showed much more damaging effects than the other coated rods worked with. A portion of the summary of Britton and Walsh's work, which included a survey of the literature and studies of a thousand welders, shows the following:

"The clinical portion of this report, based on a study of 286 welders of an average length of service of nine years, may be summarized as follows:

"1. While many hazards may exist as a result of the welding process, these can be and usually are controlled by the observance of ordinary precautions.

"2. Changes in the chest films after many years' exposure to welding fumes may occur. These changes are not accompanied by disability.

"3. In a comparatively large group of welders (about 1000) doing all types of welding, we have not observed any one disease entity to be outstanding in those disabled. Clinical syndromes in welders reported by others have not been observed.

"4. The disability frequency rate of welders has not

been in excess of that found in a general group. The diseases found have otherwise not differed from those occurring in a general group of workers.

"5. There are hazards associated with any type of welding and troubles may develop as a result of exposure to these. However, when the hazards are considered and proper safeguards taken for their control, they should no longer offer a serious menace to health."

While the Nebraska group worked with treated carbon arcs, and while their quantities of fume and gases varied to some extent, their conclusions in general bear out our own summations. They found that some high-intensity carbon arc ashes appear to cause proliferative reactions which injected intraperitoneally in rats. One statement is to the effect that rare metal salts, calcium phosphate, copper oxide and calcium fluoride appear inert. The rare metal salts mainly used are cerium oxide, lanthanum oxide, neodymium oxide and samarium oxide. It should be noted that copper sulphate and other toxic salts do cause animal death when more than 10 mg. per day are present. Also it is well known that calcium fluoride is toxic. In the gases from the carbon arc from 72 to 1500 p.p.m. of NO_2 are found depending on ventilation, type of carbon arc, intensity of current and added constituents to the carbon.

While carbon monoxide has been stated by many to be a major factor, we have not found this to be the case with metal arcs, and their experiments show none in the carbon arc. At any rate the quantities stated in the literature would be harmless. Other gases which might have been considered, such as chlorine, phosphine and arsine, are relatively unimportant. While no ozone was found in the carbon arc, we have found definite quantities which have disappeared fairly rapidly due to interreaction with NO under the influence of ultraviolet light.

It should also be noted that the Nebraska group in experiments conducted on nitrous fumes indicate that harm is caused over a $7^1/_2$-month period of time for quantities over 100 p.p.m. Our work with the metal arcs showed no harm over a considerable period of time when quantities upward of 70 p.p.m., but not over 100 p.p.m. were found in the atmosphere.

Very good agreement exists between most of the work done by Drinker and his associates and our work. In particular the studies by Tebbins of ventilation in arc welding when coated electrodes were involved confirms the statements above made and extends the material at hand in regard to the protective equipment needed. Their work indicated that the silica found was not in crystalline quartz but was probably in an amorphous form. Tebbins's work indicated also that ventilation probably is not needed except in confined spaces and that such ventilation, as is needed, becomes necessary mainly from the fume produced from coated rods rather than from the gases. Exceptional cases occur when low-boiling toxic material, such as lead or zinc, are found on the coated rods. He recommends the following ventilation rates when welding with coated electrodes:

	C. f. m.
Steel electrodes:	
$^5/_{32}$ in. or less	250
$^3/_{16}$ in.	400
$^1/_4$ in.	700
$^5/_{16}$ in.	1200
$^3/_8$ in.	1500
Alloy electrodes (fluoride coated):	
$^5/_{32}$ in. or less	250
Galvanized plate:	
$^5/_{32}$ in.	1000–1500

Tebbins also recommends suitable suction devices connected to local exhaust hoods placed within 8 to 9 in. of the arc with a minimum air velocity of about 125 ft. per minute for smaller electrodes. This ventilation experience corresponds closely with what we have found necessary on the job, though it should be remembered that in large open areas it is seldom necessary to have any ventilation due to natural air movements.

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AMERICAN WELDING SOCIETY

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Are You Wasting Oxygen?

By G. V. Slottman*

IT IS almost inevitable that in the rapid expansion of oxyacetylene welding and cutting, there should be a period when wasteful practices are prevalent. Furthermore, the wholesale addition of thousands of inexperienced operators has considerably aggravated this condition. There is no question that the conscientious welder or cutting operator is concerned about eliminating waste, when he knows its source. This article, therefore, is intended to serve as a "check-list" that will help all concerned in preventing a serious oxygen supply situation from becoming critical.

Keeping war production industries supplied with an unceasing flow of oxygen and acetylene for welding and cutting is no less essential than providing the metals needed for production. Demand for these gases has increased enormously. For some time, gas manufacturers have been hampered in their efforts to meet this demand by a shortage of cylinders to transport the gases. Now, there has arisen another source of concern. The oxygen production capacity of the oxyacetylene industry is being strained to the fullest extent, in attempting to keep abreast of constantly pyramiding oxygen requirements. In spite of additions and expansions of oxygen and acetylene plants, a critical situation faces this industry—and all industries consuming these gases—unless efforts are made by everyone to conserve, particularly in the use of oxygen.

A survey has revealed a considerable number of shop practices which might be disregarded in peacetime, but which today must be considered wasteful. These habits of yesterday, being largely unconscious, can be remedied only by a re-evaluation of the significance of such seemingly trivial practices as using the wrong size hose or torch tip, or opening up a full cylinder when a quarter-full cylinder stands idle.

The following list of recommended practices is based upon observations of correctable conditions in oxyacetylene welding and cutting shops. The elimination of wasteful practices will not only go a long way toward relieving the "tight" oxygen situation, and insuring an uninterrupted supply of gases, but will also prove economical to the individual shop where such conditions prevail. One shop, for example, was found to be unconsciously wasting approximately 25% of its oxygen consumption, through an accumulation of "insignificant" losses.

1. *Use the Proper Size Torch Tip.*—A No. 2 tip used instead of a No. 1 for cutting $\frac{1}{2}$-in. plate consumes 10 to 20% more oxygen, 16% more acetylene—all wasted.

* Manager, Applied Engineering Dept., Air Reduction Sales Company, New York, N. Y.

Fig. 4—Check Hose Periodically for Leaks. Dip Hose in Water While Under Pressure. Use Soap-Water on Connections
Fig. 5—Long Hose Is Cumbersome and Requires More Pressure. Extra Lengths Get Unnecessary Wear, Invite Leaks. Use Short Lengths
Fig. 6—Keep Cylinder Inventories Low. Order Fewer Cylinders at a Time, and Order Oftener
Fig. 7—Return Empties Promptly—Others May Need Them. Idle Cylinders Serve no Purpose. Keep 'em Rolling!

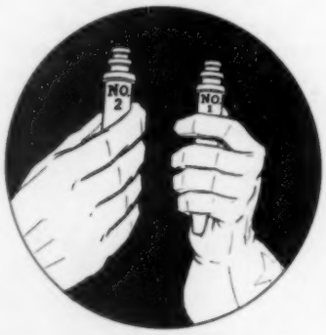

Fig. 1—Check Tip Size. An Oversize Tip Wastes Gas. If Number Is Not Clear, Check with Cleaning Drill

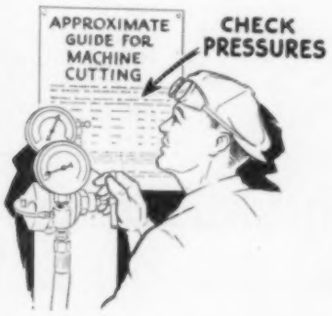

Fig. 2—Watch Your Pressure. Excessive Pressure Wastes Oxygen. Keep Pressure Chart Handy. Use It

Fig. 3—Close Cylinder Valve When Finished. Between Jobs, Release Regulator Screw, to Prevent Loss of Gas Through Hose Leakage

Fig. 8.—Don't Let Torches Burn Unused. Even 3 Minutes Out of Each Hour Means a 5% Gas Loss. Oxygen Is Precious Now. Don't Waste It

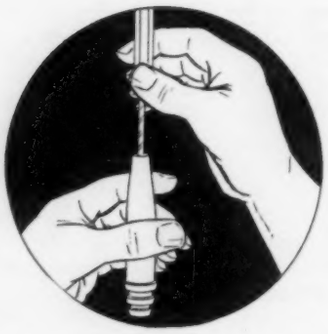

Fig. 9—Keep Your Tips Clean. Congested Tips Are Inefficient, Waste Time and Gas. Keep Cleaning Drills Handy, and Use Them

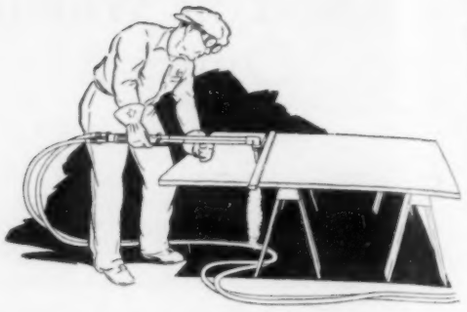

Fig. 10—Keep Hose Clear of Sparks and Slag. Avoid Serious Fire Hazards. Besides, Minute Burns Promote Leakages, and Hose Is Made of Rubber, and Should Be Conserved. Don't Mistreat It

2. Do Not Use Excessive Pressures.—This, one of the most common malpractices, is usually done by inexperienced operators who believe they thereby get a more efficient flame, or to save a trip to the pressure chart. Manufacturers' rated pressures are the most efficient for average conditions. And when more speed is desired, the new high-speed machine cutting tips cut faster without consuming additional oxygen.

3. Close Cylinder Valves When Torch Is Not in Use.—If only the torch valves are closed, gas pressure in the hose rises and may force leaks. If leaks are already present or if new leaks are forced, considerable gas will be lost.

4. Check Hose and Connections for Leaks.—They may be infinitesimal, but a $^1/_{64}$-in. diamter leak in hose operating at 100 lb. will waste 290 cu. ft. of oxygen in 24 hours—more than a tankful. The hose should be checked periodically by immersing it in water while under pressure, to show up leaks. Soap and water will reveal leaks at connections.

5. Use Correct Diameter Hose.—Hose that is too small for the job requires higher gage pressure to secure sufficient flow, causing unnecessary strain and promoting leakage in the hose.

6. Use Short Lengths of Hose.—Unnecessarily long hose also requires higher pressure, to overcome pressure drop in the hose. Also, the surplus lengths, though useless for the job, are subjected to unnecessary wear and tear.

7. Use All the Gas in Each Cylinder Before Connecting a New One.—Use every cylinder for all it is worth before disconnecting it. In the larger shops interruptions of work to change tanks can be eliminated by manifolding gas cylinders, or by installing pipe lines.

8. Keep Cylinder Inventories Low.—The old custom of keeping plenty of reserve cylinders must be abandoned, for it "freezes" them at a time when rapid turnover is imperative. Gas suppliers are cooperating by providing frequent deliveries. You can help by ordering fewer cylinders oftener, and by keeping reserves of cylinders at a minimum.

9. Return Empty Cylinders Promptly.—Idle cylinders are production slackers.

10. Don't Leave Torches Burning When Not in Use.—It may seem troublesome to be constantly re-lighting the torch, but if it burns idly for even as little as three minutes out of each hour, it is wasting 5% of its gas consumption. Five per cent of last year's industrial oxygen consumption was 360 million cubic feet. Let's use those 1,636,000 tankfuls for welding and cutting, not for heating the air.

11. Keep Tips Clean and Free from Carbon and Slag.—An unclean tip is an inefficient tip and, like any dull tool, is abhorrent to the skilled workman. Congested orifices nullify the value of using proper pressures and speeds, resulting in lower efficiency and consequent waste of gas.

12. Don't Abuse Cylinders.—A damaged cylinder must be taken out of circulation. It contributes nothing while undergoing repairs.

13. Hose: Handle with Care.—Because hose is made of rubber, it is most important that it be made to last as long as possible. To ensure this, it must be protected against mistreatment which promotes leaks. Therefore, keep hose out of range of hot oxide and sparks; wash off oil and grease, which ruin rubber; place a plank on each side of the hose where it crosses truck runways; store any hose stocks in a cool, dark place; and when a hose is damaged, cut out the bad portion and splice the ends together with standard splicing nipples.

Essentially these suggestions involve but one basic concept—to uproot yesterday's habits to meet today's demand. None of the recommendations is difficult to accomplish, provided we open our eyes to every-day practices which should no longer be tolerated. Industry needs many waste wardens; they may be unofficial, they may be self-appointed, but if they watch out for wasteful practices among themselves and their co-workers they will be performing a very real service.

ANNUAL MEETING

Cleveland—Oct. 12-16

Headquarters, Cleveland Hotel. Plan to attend. Preliminary Program will be published in July Issue.

Controlling the Effect of Contraction and Included Stresses in Welded Structures*

By A. E. Berriman†

Introduction

THE joining together of mild steel by the metal arc-welding process entails the application of heat which causes expansion of the parent metal followed by contraction on cooling of parent and deposited metal; by so doing stresses are introduced, and the effect goes by the name of distortion in welding practice.

In the detailing, manufacture and repairs of welded structures, controlling the effect of contraction and included stresses demands special attention: first, if the structural strength of the work or its suitability for service is affected, and second, as quite frequently the measures taken to control lead to increased stresses and risk of fracture. The successful application of welding largely depends upon a thorough knowledge of how contraction takes place and stresses arise, in order to control and reduce them. Therefore, this subject is of interest to all who are associated with welding.

During recent years a considerable amount of research work has been done on this subject, and with such quantitative data available, reference is made to the work of Bierett, Sarazin and Lottman. With such work as a basis, together with my own findings in practice, it is proposed to construct a picture of what happens during and after welding, and formulate a set of practical rules for the guidance of designers, welding supervisors and welders.

* Presented to Otago Branch, New Zealand Institute of Welding, August 7, 1941.

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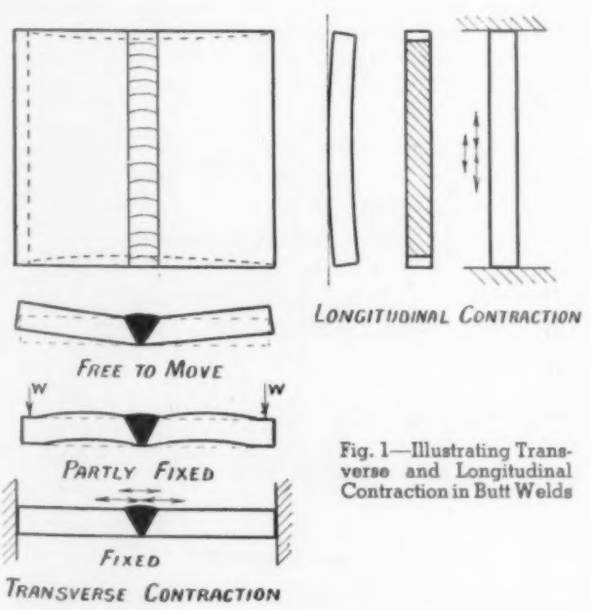
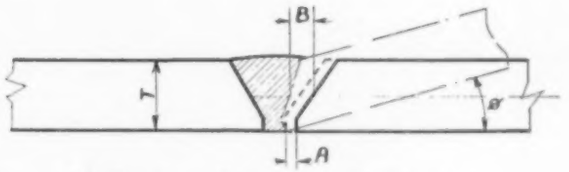


Fig. 1—Illustrating Transverse and Longitudinal Contraction in Butt Welds



A. PARALLEL TRANSVERSE SHRINKAGE
B. TOTAL TRANSVERSE SHRINKAGE
Ø ANGULAR SHRINKAGE

$$B = A + \frac{T}{2} tg\, Ø$$

Fig. 2—Component Parts of Transverse Shrinkage

The Nature of Contraction and Included Stresses

After welding the contraction of both weld and parent metal takes place, principally in two main directions, i.e., transverse (across) and longitudinal (along) the joint. Figure 1 illustrates transverse and longitudinal contraction in the butt-welded joint. It is noticed that the transverse contraction is greater than the longitudinal contraction because the V becomes narrower as the deposited metal contracts. The transverse contraction is made up of parallel and angular contraction, Fig. 2. Transverse contraction is less marked in fillet welds, Fig. 3, than in butt welds, as the zone affected by the melting process reacts on a certain part of the metal only. The transverse contraction does not depend on the thickness of the metal as in the case of butt welds, and in practice it is found to be less with heavier plates. Longitudinal contraction is practically only a fraction of the transverse contraction.

The transverse and longitudinal contraction takes place after cooling, due to unequal contraction and expansion. It is therefore evident that other stresses must be present, of which we shall term included stresses. Those that are caused by welding can be reduced to a safe value. It is interesting at this juncture to mention that plates and sections are not always free of internal stresses before welding is started.

From the foregoing elementary explanation therein lies the problem of controlling the effects of contraction and included stresses. The following main headings shall be used in building up the controlling rules:

1. Preparation of parts to be welded.
2. Assembly.
3. Welding of the parts.
4. After treatment of the welded parts.

Preparation of Parts to Be Welded

In the preparation for welding the importance of a definite system planned in sequence of operations cannot be over-emphasized before the work is started.

Divide the work up into small subassemblies and make the necessary allowances (that is, slightly longer) to counteract the contraction when preparing the material, thus making only small corrections (on the right side) when welding into the complete unit or position.

By placing the parts out of alignment or giving a slight bend or camber, the transverse, longitudinal and included stresses can be reduced and this method has proved successful in practice when the conditions are suitable. We sum up and make the first rule.

Rule 1. Make Allowances for Contraction.—As a general rule, with butt welds that are allowed to move freely will contract about $^1/_8$ in. If, however, the plates on either side are clamped or tack welded so as to restrict

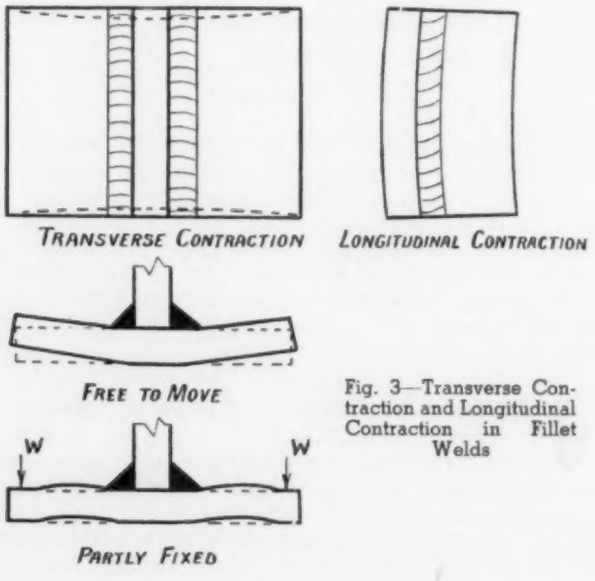


Fig. 3—Transverse Contraction and Longitudinal Contraction in Fillet Welds

their movement, the amount of contraction will be reduced to $^1/_{16}$ or $^1/_{32}$ in.

In butt welds contraction increases with increased plate thickness and the number of runs that have to be made (Fig. 4), so the recommended maximum thickness of parts to be welded by butt joints should be as follows:

Type of Butt Joint	Max. Thickness of Part, In.
Single-V	$^3/_4$
Double-V	$1^1/_2$
Single-U or single modified-U	1
Double-U or double modified-U	2

The transverse contraction can be reduced considerably by reducing the cross section of the joint, Fig. 5, and conditions can be improved by using symmetrical joint section and welding alternately on each side; therefore we comply with the following rule:

Rule 2. Prepare the Joint so That Only the Minimum of Weld Metal Is Required.—The edges of parts to be welded should be prepared in accordance with a recognized

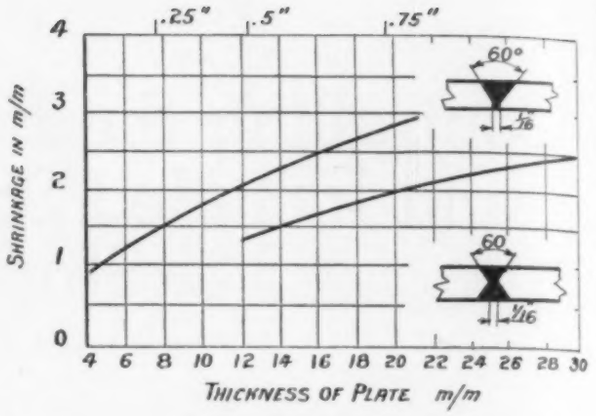


Fig. 4—Transverse Shrinkage of Butt Welds of Well-Tacked Joints

Welding Code.[1] Figure 6 shows the preparation of single- and double-V, single- and double-U butt joints. The minimum dimensions are recommended taking into consideration the welding position.

Assembly

Having the parts to be welded free and thus allowing for the contraction, good results are obtained, but as this method is not always possible, a second method may be used; that is, the partly fixed condition obtained by tack welding, clamps, screws, jigs and fixtures. In this method we take advantage of the weld metal while in the plastic state and contraction is balanced by stretching the weld metal. The metal must be sufficiently ductile to allow the shrinkage to take place without affecting the soundness of the joint.

The partly fixed condition, if properly carried out, will considerably reduce the contraction and where such contraction does occur, its course will be along parallel lines. This contraction and any included stresses can be reduced by welding methods as will be seen later. Therefore we formulate the rule:

Rule 3. Use Means of Holding the Work and Thus Obtain a Partly Fixed Condition.—When using tack welds it is advisable to use tacks $^3/_8$ in. to $^3/_4$ in. long, spaced at distances along the joint in proportion to the length. Operations that have to be repeated in the manufacture of similar articles can be substantially reduced by properly designed work holding devices.

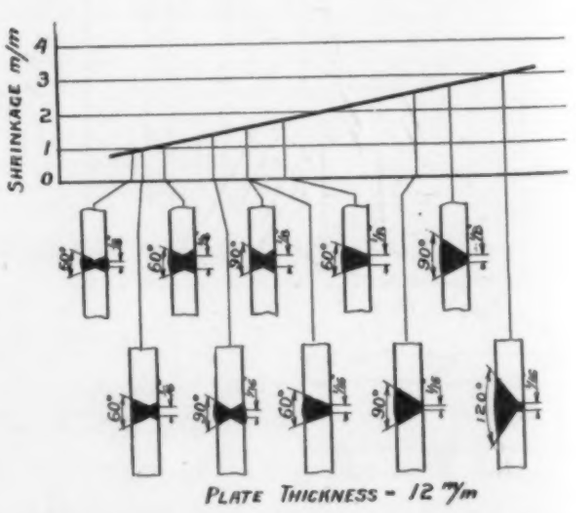


Fig. 5—Shrinkage of Butt-Welded Joints of Different Shapes

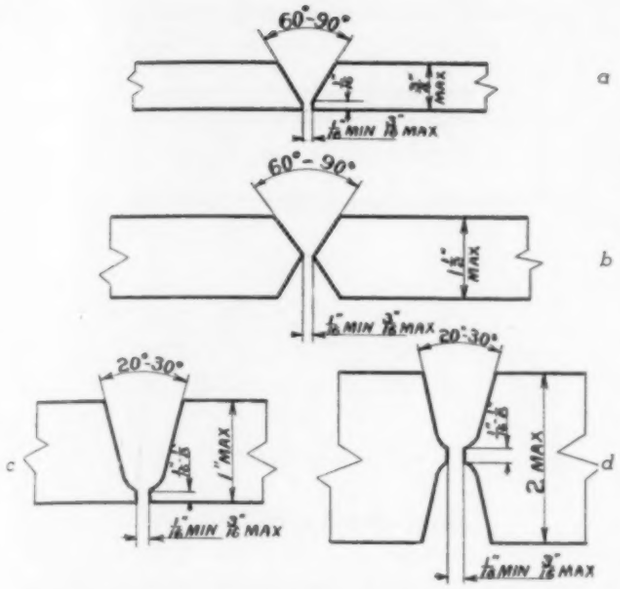


Fig. 6—Preparation of Single and Double U and V Butt Joints

a—Single V butt weld
b—Double V butt weld
c—Single U butt weld
d—Double U butt weld

A third method in the erection and welding has to be dealt with, that is, the fixed condition. The partly fixed condition angular contraction has been taken care of, but the parallel contraction has to be considered as dangerous stresses may be produced. To avoid such conditions we make the following rule:

Rule 4. Arrange the Erection and Welding of the Parts so That They Have as Long as Possible Freedom to Move in One or More Directions.—A good example to illustrate this rule is the welding of a patch into a large plate, as shown in Fig. 7. The patch is dished and tack welded into position and joint 1 is welded, then 2, during which joints 3 and 4 have freedom to move, then 3 and 4 are welded and on cooling the patch will straighten.

Welding of the Parts

In starting to weld any structure the joints that cause the most contraction stresses should be made first while the parts still have freedom to move. The longitudinal stresses are less than the transverse as shown in Fig. 8, and this gives an indication of the joints to be welded first, that is, butt-welded joints followed by fillet-welded joints.

From this information we formulate the following rule:

Rule 5. Start by Welding the Joints That Cause the Most Contraction Stresses First.—When the weld metal is deposited in the joint we have a high and an abrupt drop in temperature. The colder parts of the plates act as a sort of buffer and the heat, coefficient of expansion which is not stable at high temperatures, induces plastic "upsetting" in the very hot heat zone, this being the real cause of longitudinal contraction and contraction stresses.

According to tests made by Sarazin, it is safe to say that the contraction of the weld metal is responsible for about one-third and the contraction and upsetting of the plate for two-thirds. Therefore, the heat introduced into the material plays a large part in the amount and nature of the contraction stresses.

To understand the stresses accompanying temperature changes, the physical properties of mild steel at various temperatures, Fig. 9, must be taken into consideration. It is noticed that the tensile, elongation and reduction of area reaches a maximum value at between 200° to 300° C., which is usually called the "blue temper range." The tensile and the yield points, though not well defined,

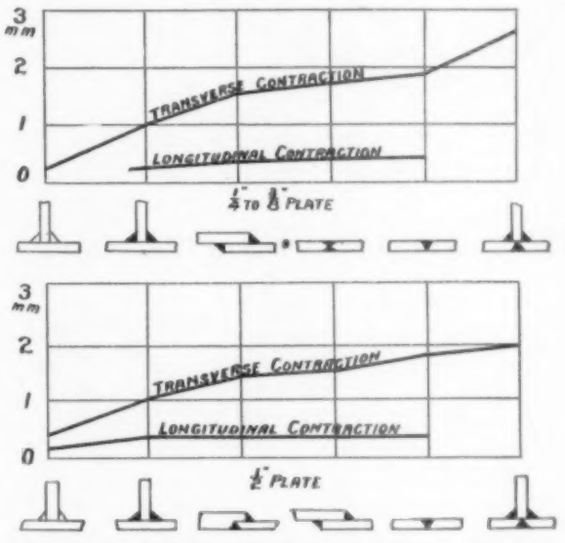


Fig. 8—Longitudinal and Transverse Stresses in Different Welded Joints

decrease rapidly at higher temperatures, and at 600° to 700° C. the numerical value of the yield point is very low. It is in the 600° to 700° C. heat zone that the maximum of plastic upsetting will take place.

If the upsetting zone is narrow, a high tensile stress is induced in the weld zone. When the zone of heat is wider, the greatest upsetting will be away from the weld, the upsetting gradient will be smaller and so will the maximum stresses, but on account of the greater area involved, the total stress will be greater and distortion will be considerably increased.

To obtain a narrow heat zone the joint should be made in the shortest time, so we make the following rule:

Rule 6. Deposit the Greatest Amount of Weld in a Unit of Time.—To obtain such conditions use the largest gage electrode and take advantage of the higher current values recommended by the manufacturers and thus obtain a greater welding speed. The gage of electrode and size of run should be in accordance with a recognized Welding Code.[1]

The stresses that are set up by the welding process may

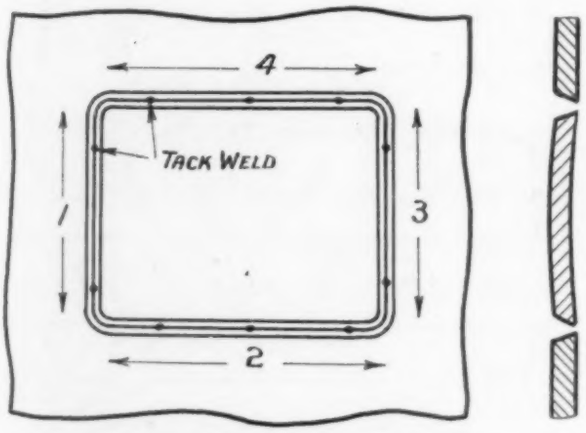


Fig. 7—Method of Welding a Patch in a Plate

be prevented mainly by welding methods. In this connection the sequence followed when welding, together with the speed of welding and number of runs made, are important.

The welding sequence should be such that an even distribution of heat is obtained. Starting the welding in the center and working out, place compressive stresses at the ends of the joint; this has the advantage of a certain natural safety factor, Fig. 10. The tension stresses can be reduced by the "Step Back" welding method, as shown in Fig. 11, if more than one run is required by alternating

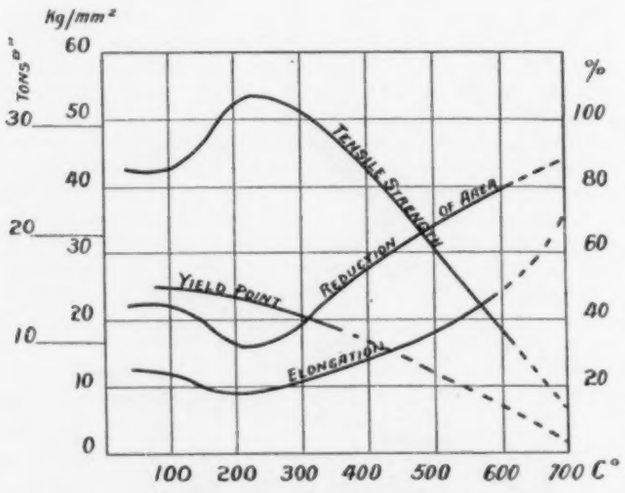


Fig. 9—Strength Properties of Steel at Various Temperatures

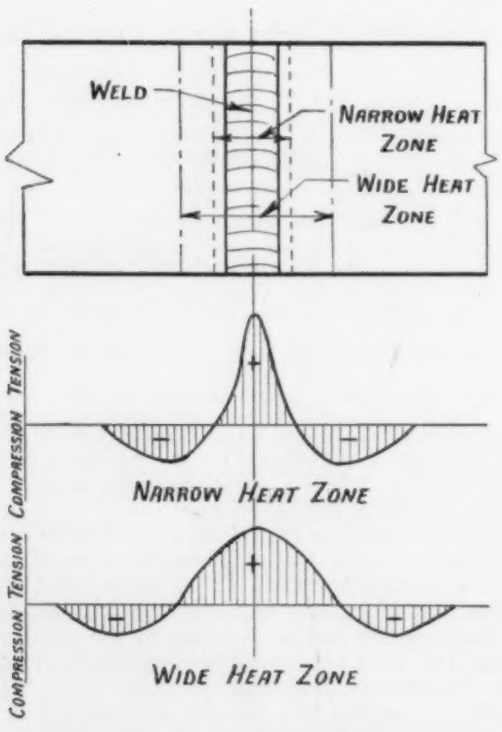


Fig. 9 (a)—Narrow and Wide Heat Zones

the main direction, or by continuously welding in alternating directions.

Welding in stages should not be used as they tend to set up intense transverse stresses as shown in Fig. 12.

To obtain the even distribution of heat during welding we make the following rule:

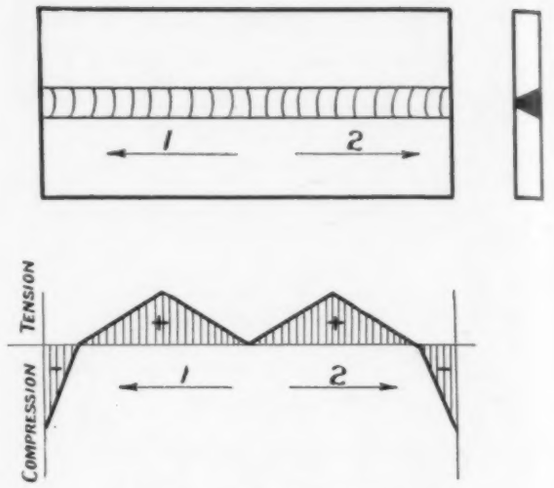


Fig. 10—Welding from Center Out

Rule 7. Distribute the Heat as Evenly as Possible Over the Length of the Joint by "Step Back" Welding Methods.—To obtain an even distribution of stresses the material must be allowed to cool at a slow rate. Accelerated cooling by artificial means will, as a matter of fact, prevent bending and warping, but stresses will be increased. Such measures should not be used when welding structural steel work.

Welders should comply with the following rule:

Rule 8. Allow the Heat to Escape from the Welded Joint Without Any Artificial Means.—Contraction stresses set up during welding have a tendency to produce cracks, that is, if the shape and size of the weld are not in proportion to the thickness being welded. Cracks appear in the 200° to 300° C. temperature range, but probably they occurred at much higher temperatures. In heavy sections preheating before welding, if intelligently applied, reduces the risk of cracking.

With reference to fillet welds, shown in Fig. 13, the force lines follow an unrestricted course when the weld section is convex and an interrupted course with convave weld sections, this being why such weld sections crack more easily. The size of fillet welds should be in propor-

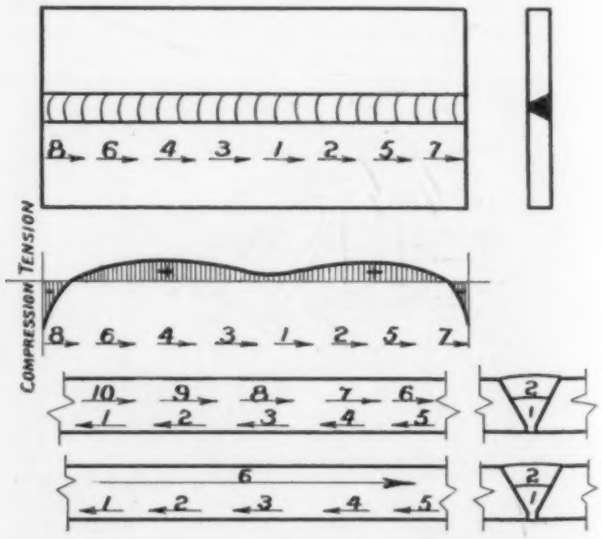


Fig. 11—Step-Back Welding Methods
Arrows indicate direction of welding.

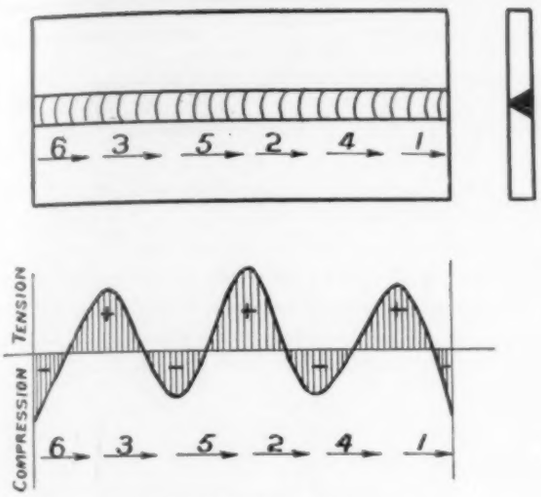


Fig. 12—Welding in Stages

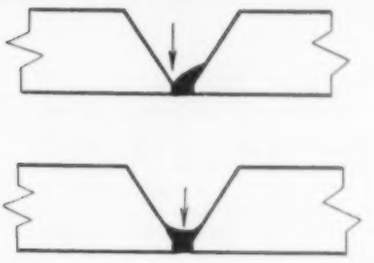


Fig. 14—Danger of Cracking When Shape of Deposit Is Incorrect

Fig. 15—Stress Concentration in Deposited Metal

tion to the plate thickness, and in accordance with a recognized Welding Code.[1]

With butt welds the incorrect shape of the deposit, as shown in Fig. 14, will induce cracks. When the deposit is too small in comparison to the thickness of the plates, particularly so with the first run, cracks will occur because of the stress concentration in the deposited metal, Fig. 15.

In order to avoid the occurrence of cracks, welding should proceed without interruption until the V is filled up to a safe height. When welding symmetrical butt joints it is recommended that two runs be made on one side before doing the other; this is also important if the work has to be turned over to carry out the welding.

To avoid the occurrence of cracks we formulate the following rule:

Rule 9. Never Leave a Joint to Cool Until the Weld Has Reached a Safe Size or Thickness.

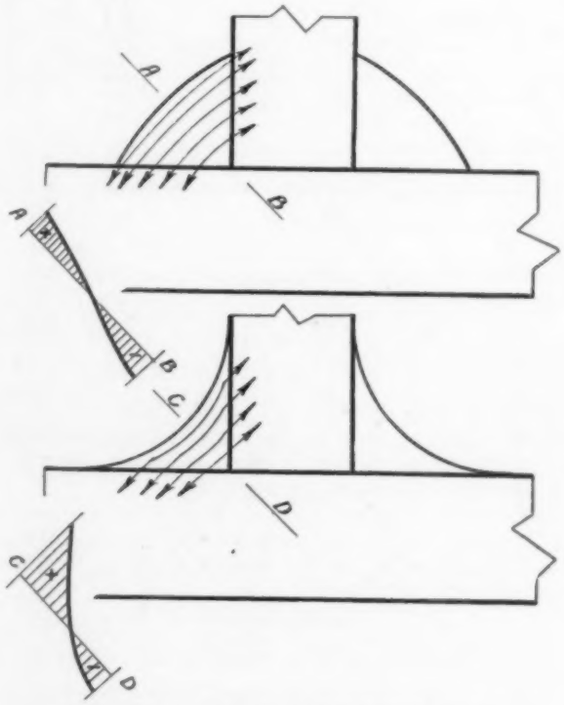


Fig. 13—Fillet Welds. Effect of Contraction

After Treatment of the Welded Parts

After welding, any dangerous included stresses that still remain may be removed by appropriate mechanical (that is hammering) or heat treatment with an oxy-acetylene torch. By heat treatment is meant the application of heat during or after welding, preventing cooling of a quenching nature. When applied during welding it will reduce risk of cracking, and also obtain a more equable tensile condition along and across the weld.

By mechanical treatment to the parent metal (pneumatic hammers are sometimes employed for this purpose) the stresses can be equalized and included stresses reduced, and it is considered that the best results are ob-

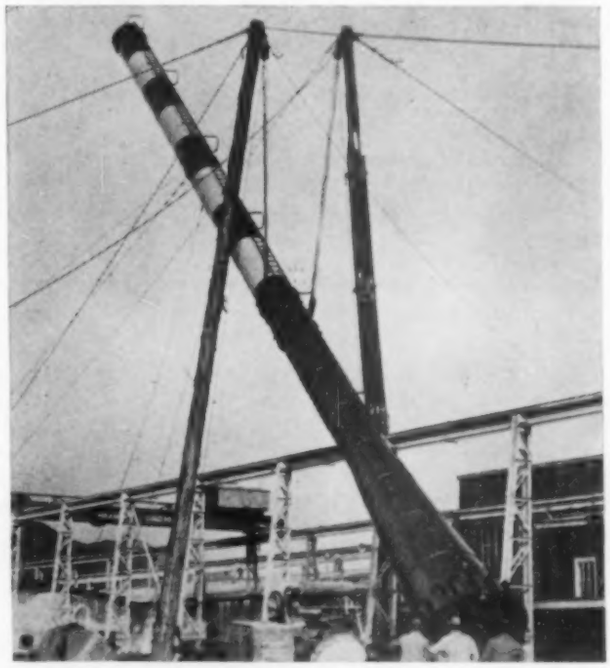


Fig. 16—The Welding of a Mild Steel Chimney 120 Ft. High, Weight 10 Tons. Railway Workshops

Rules used during manufacture Nos. 1, 2, 3, 4, 6, 7, 8, and 9. Longitudinal joints butt welded. Circumferential joints fillet welded inside and outside. Made in four sections in the shop and delivered to the site where the welding was completed. The chimney was erected in one piece.

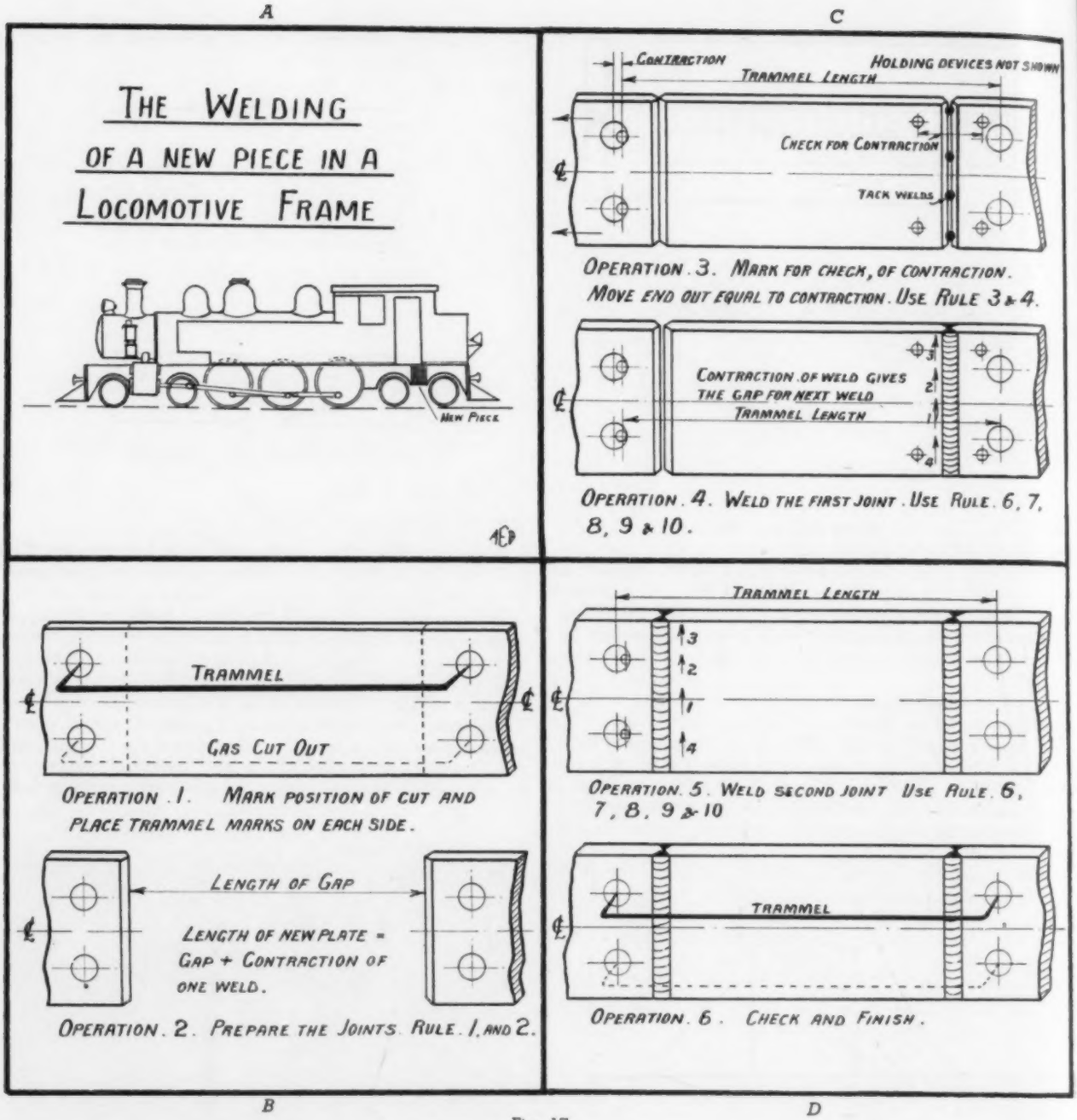

A
C
THE WELDING
OF A NEW PIECE IN A
LOCOMOTIVE FRAME
NEW PIECE
CONTRACTION
HOLDING DEVICES NOT SHOWN
TRAMMEL LENGTH
CHECK FOR CONTRACTION
TACK WELDS
OPERATION. 3. MARK FOR CHECK, OF CONTRACTION. MOVE END OUT EQUAL TO CONTRACTION. USE RULE 3 & 4.
CONTRACTION OF WELD GIVES THE GAP FOR NEXT WELD
TRAMMEL LENGTH
OPERATION. 4. WELD THE FIRST JOINT. USE RULE. 6, 7, 8, 9 & 10.
TRAMMEL
GAS CUT OUT
OPERATION. 1. MARK POSITION OF CUT AND PLACE TRAMMEL MARKS ON EACH SIDE.
TRAMMEL LENGTH
OPERATION. 5. WELD SECOND JOINT USE RULE. 6, 7, 8, 9 & 10
LENGTH OF GAP
LENGTH OF NEW PLATE = GAP + CONTRACTION OF ONE WELD.
OPERATION. 2. PREPARE THE JOINTS. RULE. 1, AND 2.
TRAMMEL
OPERATION. 6. CHECK AND FINISH.
B
D

Fig. 17

tained by hammering outside the weld zone. Hammering the weld metal is not recommended as this has the tendency to cover up poor workmanship. Should the weld metal not be subject to microscopic cracks or brittleness by hot or cold working, hammering the weld metal by those who have an expert knowledge concerning the material being used will obtain good results.

Work which has been distorted as the result of welding can be straightened by mechanical or heat treatment.

To finish off the work we make the following rule:

Rule 10. Mechanical or Heat Treatment Assists in Equalizing Stresses and Reduces Included Stresses.— It is now proposed to illustrate how these rules have been applied in actual practice:

1. The welding of a steel chimney 120 ft., 0 in. high, and weighing 10 ton (Fig. 16).
2. The welding of a new piece in a locomotive frame (Fig. 17).

Conclusion

The ten rules that have been developed to control the effect of contraction and included stresses in welded structures will enable a high standard of perfection to be obtained.

Welding specifications generally state that "the welding sequences shall be such as to minimize distortion and contraction stresses." Such requirements are fulfilled by using the controlling rules.

In this short paper it is hoped that a better understanding of one section of welding procedure has been obtained that will contribute to the improvement and advancement of welding.

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[1] *The Proposed New Zealand Standard Code of Building By-Laws*, Part VIII. The application to building construction of the metal arc welding of Mild Steel Workmanship.

Welding of Light Gage Steel Tubing in Aircraft Production*

By Joseph P. Weed†

AMONG the many recent revolutionary advances in methods of aircraft fabrication, none holds a higher place than does the successful application of electric arc welding to the construction of assemblies of light gage SAE X4130 chrome-molybdenum tubing. The change from the oxyacetylene method came as a result of a demand for increased production with a consequent need of reducing both time and costs of manufacturing. The challenge presented by the increased tempo was more than met and as a result, welding is not only not a bottleneck but shows itself to be one of the most versatile tools available to the industry for the lowering of cost with a simultaneous increase in production speed.

But as with many another such change, the solution was not forthcoming for the asking. The almost explosive appearance of arc welding in this field was accompanied by many problems which required extensive work before they were solved. It is with these problems and the answers to them that we are concerned.

The foremost consideration in any welded primary structure is that the weld be strong and ductile. Unless this can be achieved, no further consideration will be given to any welding process. A normal weld in X4130 steel employing the electric arc with a heavily shielded mild steel electrode will have a tensile strength of 85,000 to 95,000 psi. with an elongation of 12 to 15%.

These figures are from data taken during several months of laboratory and shop research on production parts.

The cost factor is also of great importance and interest. Arc welding will reduce the cost of fabrication 65 to 75% as compared with the cost of former methods. Since "setup," tube fabrication and alignment times remain at about the same levels for either process, the savings result from three chief items. Speed of welding with a resultant lowering of man-hours required per part is the most important factor, the favorable difference in cost of electric power with lessened cleanup and straightening time forming a smaller part.

As an example of what may be expected in the way of increased production at reduced cost consider that welding crews have been reduced 75%; the number of jigs 60 to 75% and production rates have not only not suffered, but in some instances have actually increased.

Only in one feature does arc welding fail to excel: that one feature is weld appearance.

Arc Generators

The first problem encountered in the change-over was that of obtaining an arc generator having characteristics suitable for this type of work. This was made increasingly difficult because neither the generator manufacturers nor the welding operators knew exactly what was desirable and there was little or no data available from other sources to serve as a starting point. Arc generators designed to the limits of the present NEMA standards, though suitable for heavier welding or for less highly stressed light gage welding, were far from satisfactory in their current control for work on aircraft tubing. Machines with compensating controls are of little value because in the lower ranges the open circuit voltage drops too low for the "hot start" that is all important in this type of work.

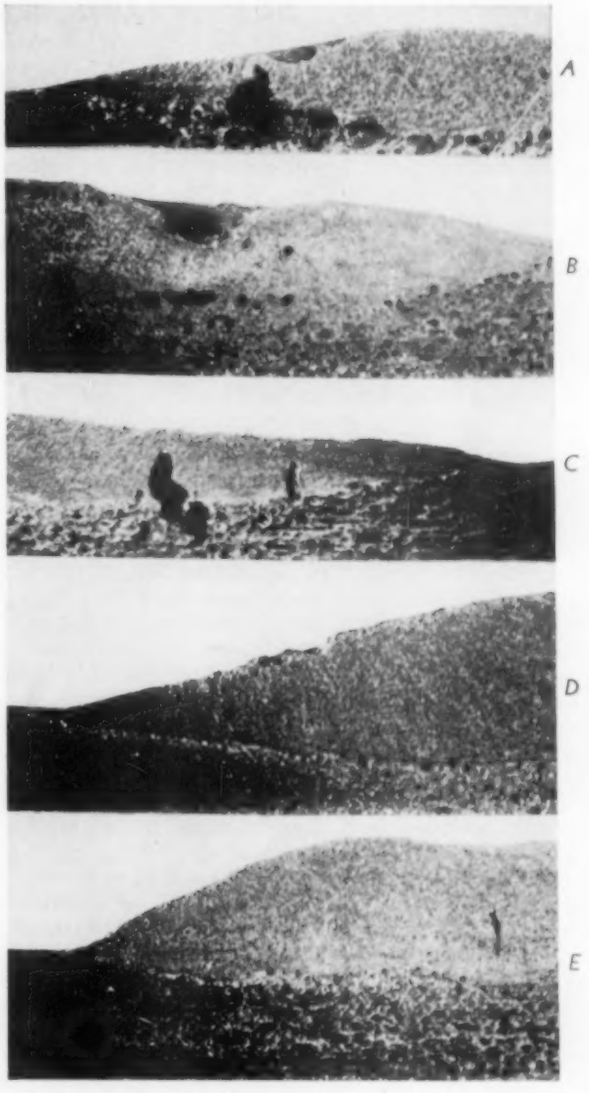


Fig. 1—Cross Section of X4130 Steel Arc Welded
Macrophotographs *A*, *B* and *C*: Without Crater Eliminator
Macrophotographs *D* and *E*: With Crater Eliminator

* Presented at Jan. 15, 1942, Meeting, Los Angeles Section, A.W.S.
† General Welding Foreman, North American Aviation, Inc., Inglewood, Calif.

After investigation of several generators available in the market, some of which performed to a large degree of satisfaction, others of which were entirely unsuitable in ranges below 60 amp., the following specifications were set up. These specifications are for an ideal arc generator and none has been found that has all these characteristics, possibly because they have not been needed before. The arc generator to be used in the welding of light gage X4130 material should have an open-circuit voltage range of 75 to 85 v., with a continuous current range of 20 amp. to capacity. The extreme amperage setting on the high side need not be over 125 amp. since values this high are rarely used in aircraft construction. The generator should have a high recovery from the shorted condition that occurs during the striking of the arc. Low speed of the arc generator is important to insure quiet operation and freedom from other than normal maintenance service. The need for the high open-circuit voltage is quite apparent when it is realized that little or no puddling occurs in welding of this extremely thin-walled tubing. The dangers of "falling through" and of the addition of unnecessary weld materials are present to a very great extent if puddling is attempted. Because of this, the "hot start" or "surge" of a high open-circuit voltage is imperative. Unless this "hot start" occurs at the start of a weld, poor penetration or cold lapping results; both are highly undesirable in aircraft welding and neither can be tolerated. Continuous current control must be had, for variations of 2 or 3 amp. are highly important on tubing with wall thickness as low as 0.035 in. When using $^1/_{16}$-in. diam. electrodes, currents drop as low as 20 to 25 amp. and produce good results with high open-circuit voltages. It has been found that even penetration of the bead from the start to the finish of the weld results only when the recovery rate of the arc generator is very rapid. This quality of penetration at the start of the weld is in direct ratio to the rate of recovery of the generator and this factor is extremely important to good aircraft welding practice. When these design factors will have been incorporated into one arc generator, a great stride will have been made in the direction of increasing quality and speed of aircraft welding.

Arc Electrodes

In consideration of the careful selection of an arc electrode three important questions arise: (1) is the electrode manufactured under such conditions that uniformity of quality will be maintained, (2) is the electrode manufactured in the desired sizes and (3) is the supply sufficient to meet reasonable demands? If these can be answered to satisfaction, the next step is to determine the types which best fulfil these additional requirements: (1) the electrode should be of mild steel, (2) should deposit filler metal having high strength and ductility, (3) should have low spatter loss and ease of control and (4) should be a "cold electrode" having as much uniformity of the coating as is possible.

The term "cold electrode" as it is used in aircraft arc welding designates an electrode that on low-current settings will have a large burn-off ratio with little depth of penetration into the parent metal. One of the most serious conditions existing today in the arc welding of aircraft structures is the lack of uniformity in coatings on heavily shielded electrodes. This lack exists not only in the variation of the thickness of the coating itself, but has a still more serious side in that the electrode wire may not be centered in the coating. A slight variation in the over-all diameter of the finished electrode in the smaller sizes results in comparatively large changes in volume of the materials in the puddle. These necessitate constant resetting of the generator when using these electrodes. The lack on concentric alignment of wire and coating also results in poor arc control causing cold laps, welding on one side, split welds and lack of fusion at the root of the welds. The market offers several electrodes having all the necessary requirements for good arc welding of light gage tubing except that of uniformity in the manufacture of the electrodes. This condition, however, is rapidly improving and is expected to continue to improve now that electrode manufacturers realize its importance in the successful welding of light gage tubing.

For heat-treatable applications an electrode is used having all the above mentioned characteristics, except that the wire be an alloy steel whose weld deposit approaches the analysis of X4130.

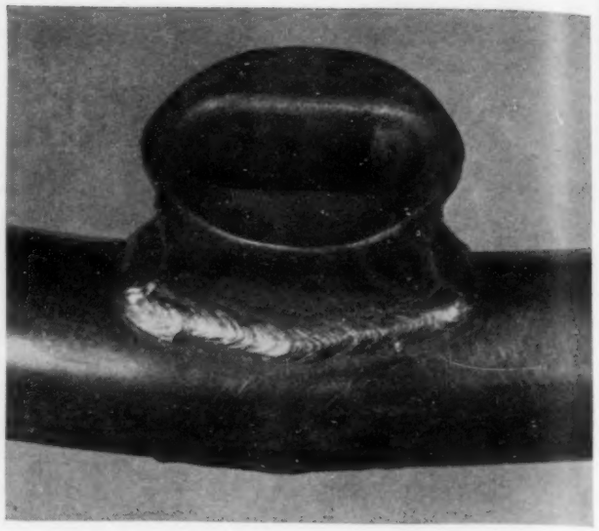


Fig. 2—Arc Welded Lug on Motor Mount

Tooling

The use of proper jigs and tooling in the fabrication of welded structures cannot be too strongly emphasized. Changes from tooling used with the oxyacetylene process to those designed for arc welding should occur almost without exception. Stress should be put on accessibility from the operator's point of view. The basis of design for arc welding is quite simple. All jigs should be so mounted that they can be revolved 360° about two axes, 90° opposed. By this means almost every joint in an assembly can be put in a position for flat welding. In extremely large structures this cannot be accomplished, but even these should rotate 360° about one axis. If jigs are constructed with this idea in mind production rates will attain much higher levels than before with less fatigue to the operator, and welds of much better quality and appearance will result.

Crater Elimination

Since high factors of safety are required in aircraft structures, the formation of flaws in weld endings caused no small amount of worry and indecision before the adoption of electric arc welding was approved. Small fissures or cracks form in every weld ending and are extremely serious because of the thin walls of the

tubing and the small deposit of weld metal. The seeming impossibility of totally avoiding these flaws resulted at times in the temporary rejection of the electric arc process.

To alleviate this problem there has been developed and marketed a motor-controlled rheostat or series of rheostats known as the crater eliminator. By rigorous testing, it was proved that this device actually eliminated the subsurface craters that are formed in weld endings when this control is not used.

The eliminator introduces a resistance into the exciter circuit of the generator and when set into operation causes a slow and uniform quenching or "pinching out" of the arc. This permits the puddle to cool slowly from the edges toward the center and a "pipe" does not form as in the case when the electrode is quickly removed and the arc is suddenly broken. The addition of uniformly diminishing amounts of metal to the hot center of the weld puddle allows the metal to cool and shrink without leaving a fissure. The result is a weld ending that is made of sound dense metal.

The need for such control is more apparent when it is realized that it is possible to finish welds in such manner that subsurface craters are not apparent to visual inspection and in addition, because of the small size, the flaws may also pass magnetic inspection. No indication of the unsafe weld comes to light until the joint fails in service, often with disastrous results.

The usefulness of the crater eliminator is not limited to this one feature. Its application as a remote control of the current delivered by the arc generator without affecting to any great degree the voltage maintained is very important. This characteristic permits the arc generator to be set at the highest required current and allows the operator to weld over light and heavy sections without resetting the generator as he employs the crater eliminator to vary the delivered amperage. This greatly reduces the idle time of both operator and generator as well as producing more satisfactory welding. The eliminator has proved so important in this field of work that operators who have used it for any length of time find it extremely difficult to produce, under any other conditions where varying thicknesses of material occur, welds of equal average quality. The intelligent use of the crater eliminator has met with some opposition because the small flaws that it removes, although very dangerous to the entire assembly, are not readily recognized. Operators resent very strongly the use of this instrument because they feel as most supervisors did at the start; it appears to be too much machinery for such small results. Only by the continual study of specimens which are cut and etched for examination of structure by close comparison of welds made with and without this device can its importance be fully understood. Universal use of the crater eliminator is predicted in connection with light gage welding in the future.

Development of Procedure

The problem that perhaps had most to do with the first failure in the arc welding of X4130 was the entire lack of information of the welding process as applied to light gage tubing. This lack of knowledge existed not only among our top ranking engineers but through the ranks to the lead man and the welder in the shop. This was, of course, a natural condition because in the building of aircraft structures in previous years, oxyacetylene welding was fast enough for production work and the results obtained by the older welders in the aircraft field using this process were works of art as far as appearance went. When the need for increased production suddenly arose, the demands were increased to such a point that something had to be done to increase production rates. The industry suddenly found itself lacking men with the necessary knowledge of arc welding in this field and no ground work of value in the field of research that could be applied. Faced with this condition, it was at first necessary to find capable welders who would apply the knowledge that they had accumulated through years of experience in other branches of the trade to an entirely new branch of arc welding. This has gradually developed a class of supervisors who hold within their own group most of the information available in the successful arc welding of light gage tubing. As these men were developed, they passed their information down through

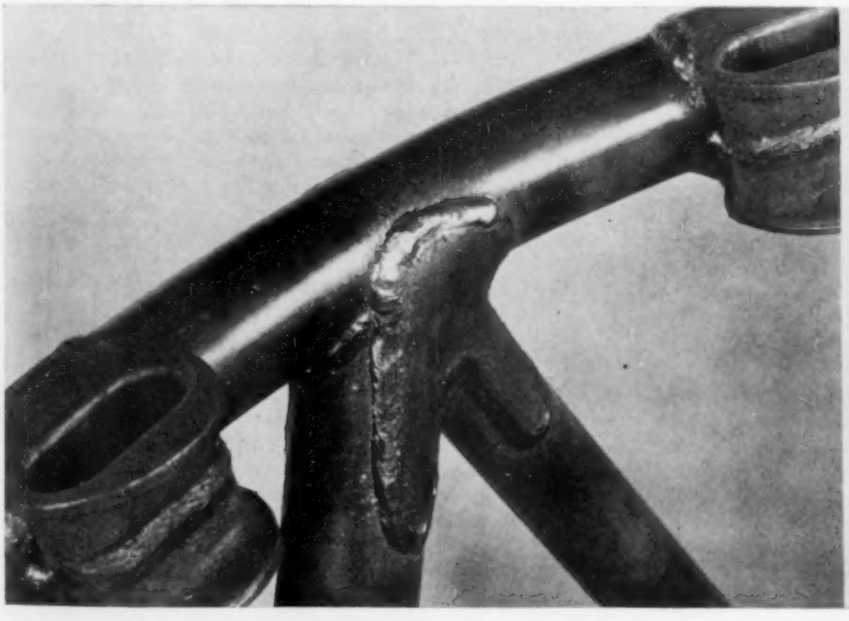


Fig. 3—Arc Welded Gusset Plate Motor Mount

Fig. 4—Arc Welded Tube to Solid Fitting Motor Mount

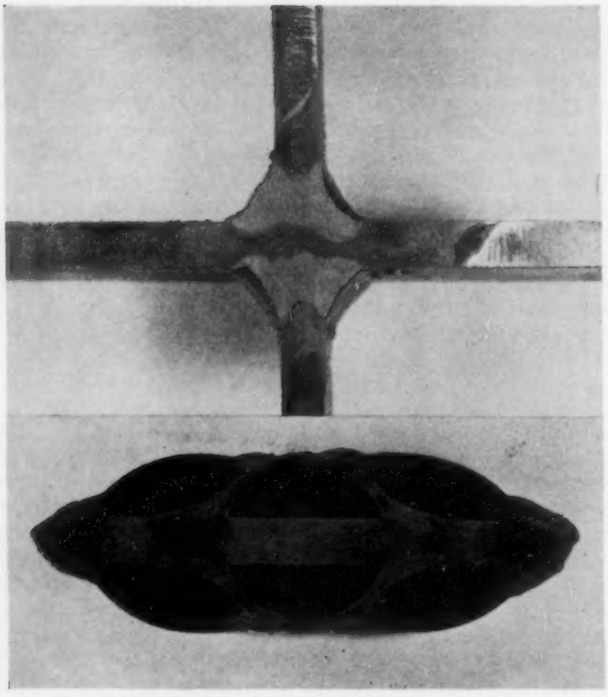


Fig. 5—Arc Welded Joints

the ranks, training those under them. There were some failures at this stage of development because of the lack of ability on the part of supervisors to "put over" their knowledge and because of unwillingness of aircraft welders to change from the older, and for them the easier, oxyacetylene process. When the prejudiced welders eventually were convinced of the superiority of the new method things began to develop in a faster, more vigorous fashion because of suggestions and improvements made in all phases of the new field by the operators themselves.

Simultaneous with this development, research was carried on both in the laboratory and in the shop in an effort to provide a practical procedure for production welding of light gage tubing.

The first results proved the methods employed in other fields were not adaptable to aircraft welding. Trial and error methods were resorted to and produced several interesting and important facts. In the welding of thin walled tubing the opposite procedure of that used in pipeline and tank construction or in general maintenance work must be used. These require high current and low-voltage settings, while in aircraft work the current is kept low and the open-circuit voltage high. The puddling occurring when heavy electrodes and high currents are used eliminates the necessity for a high open-circuit voltage to produce a "hot start" or instant penetration. However, in welding thin walled tubing the high rate of deposition of weld metal with a consequent lack of puddling makes an extremely high open-circuit voltage imperative. Any attempt to gain penetration at the start of the bead by puddling will invariably result in lack of uniformity of depth of penetration or the deposition of unnecessary amounts of weld metal.

Low current settings initiated the search for a "cold electrode," i.e., one which will "burn off" rapidly at low settings and thus will prevent extreme penetration into the base metal.

Experiments with bead types lead to the conclusion that the single pass bead was the most desirable. All other types produced results which were far less satisfactory. An example of this is the case of the double pass bead. Using a stringer bead as the base weld, a second weave bead was laid down to cover the first. The result was a high percentage of cracks caused for the most part by one factor. In putting in the stringer bead, the material is pulled against the retaining parts of the jig, thereby setting up shrinkage stresses in the material. As the second pass is put in, the material is subjected to localized heating from the arc with the result that as the metal passes through its hot short range, cracking occurs. With the single pass bead this does not occur and it cannot be stated too emphatically that in all cases of arc welding of light gage X3130 tubing, the single pass bead is far superior from every standpoint.

Training of New Operators

In training new operators, the period required will be far shorter in the case of electric arc welding than that which will produce equal results with the oxyacetylene method. There are several reasons for the fact that less time is consumed in training. One is that only one hand is required and therefore less muscular coordination is necessary.

Training welders experienced in other fields of arc welding or the conversion of aircraft operators from oxyacetylene is relatively easy as far as the physical characteristics of the process are involved. Even extreme cases require only about 50 hr. of closely controlled instruction and very often the training period lasts but 15 or 16 hr. Careful observation of the student's progress is essential to preclude his acquiring bad habits or poor methods. As with other periods of instructions these habits are readily formed and difficult to break later.

Inspection

Not only most operators be reschooled in changing from the oxyacetylene to the electric arc process, but the inspectors must be educated in the differences between the arc and the gas weld.

New inspection methods must be initiated. The inspectors must be shown that appearance is not a criterion on which to judge a weld.

While this may appear to be a minor problem, the frequent rejections before this is realized may cause considerable loss in production time with a consequent increase in cost.

Processing

Processing before welding is not very different for either method. Melting when using the electric arc process requires a little more careful checking of tolerances keeping the joints to closer fits. This is possible because of the lessened heat applied by the arc.

Cleaning after arc welding is simpler and less expensive. Sandblasting is satisfactory and the removal of the flux coating is less difficult than is the removal of the scale from oxyacetylene welding.

Because the electric arc produces a much narrower heat some re-alignment time required after welding is lessened at least 50%.

Complete normalizing of the arc-welding structure is very rarely done. It is unnecessary except for those

cases where normalizing would be required regardless of the method of fabrication. Stress relieving is used only to correct misalignment of the structure.

If the welding be properly done the joint will be strong and ductile and heat treating to improve its quality should be unnecessary.

The one exception to this is the requirement that an assembly be heat treated to increase its strength as a whole and then an alloy steel filler metal is used.

Conclusion

Production rates have increased and operating costs have been reduced beyond the highest estimates.

Shared effort on the parts of the equipment manufacturers and the aircraft industry will yield valuable dividends, and these improvements will continue as equipment is bettered and as the operators' skill in use of the new tool increases.

Some Comments to the Design of Welded Pressure Vessels*

By H. F. Lassner†

CONCEIVED by outstanding specialists and worked out in every detail covering the design and fabrication of pressure vessels, the A.S.M.E. and the A.P.I.-A.S.M.E. Codes for unfired pressure vessels have proved their high value to plate fabricators and to users of such vessels as well. However, in many respects these rules represent a compromise of views, which naturally are undergoing changes in accordance with the experience gained in operation, and with the increasing insight in the factors governing design and selection of materials for constructions of that sort.

In this emergency, when the enormously increased production creates a heavy demand for rolled steel which the mills are unable to meet, an utmost economy in the amount of used plate becomes daily more urgent. On the European continent, where labor is not as preponderant a factor in costs as it is in this country, economy in materials is a tradition. There it has always been forbidden to use even fractions of a millimeter in thickness of rolled stock exceeding the minimum required by strength calculations and safety requirements.

Fortunately we could afford a certain generosity in heavier stock than absolutely necessary, thus often obtaining sturdier constructions resulting in greater longevity. This kind of luxury, however, should cease, as long as the emergency lasts.

Reinforcing Rings

The following will show an application of the above principles in pressure vessel design. Both codes call for reinforcement of welded openings under certain conditions. The codes give the designer sufficient freedom in choosing his way of making up in strength for the metal removed from the vessel wall. However, many designers follow a sort of routine procedure in going through the computation specified in the Code. They let the nozzle neck (Fig. 1A) end flush with the inside shell, and obtain the reinforcement mainly through a reinforcement ring welded to the outer shell and nozzle. This method is entirely correct. It is safe but, in many instances it is not the most economical.

By having the nozzle wall extending into the inside of the vessel for a moderate amount (Fig. 1C), two advantages may be obtained: (1) the fillet weld between inner shell and neck requires no edge preparation of the hole in the shell, as would be required in a flush condition of neck and shell; (2) together with the neck area inside the vessel wall it may very often furnish the required addition to the area of reinforcement available in vessel and nozzle walls within the vessel thickness ($\times 2$) and to the nozzle metal outside the vessel wall available for reinforcement ($\times 3$). The neck area inside the shell adds to $\times 3$, and the fillet welds inside and outside the vessel wall gives $\times 1$. In both areas eventual corrosion has to be considered by suitable deductions.

This solution has, of course, its disadvantages. It is not feasible, wherever the inside vessel wall has to be flush, or with tanks of small diameter, when it is im-

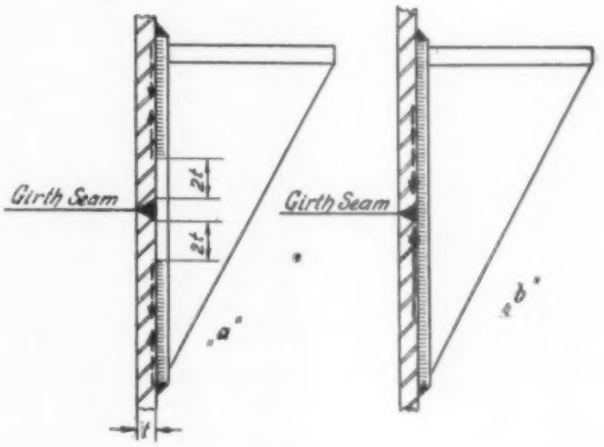


Fig. 2

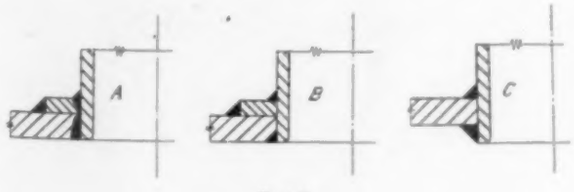


Fig. 1

* The Society assumes no responsibility in presenting the views expressed herein.

† Consulting Engineer.

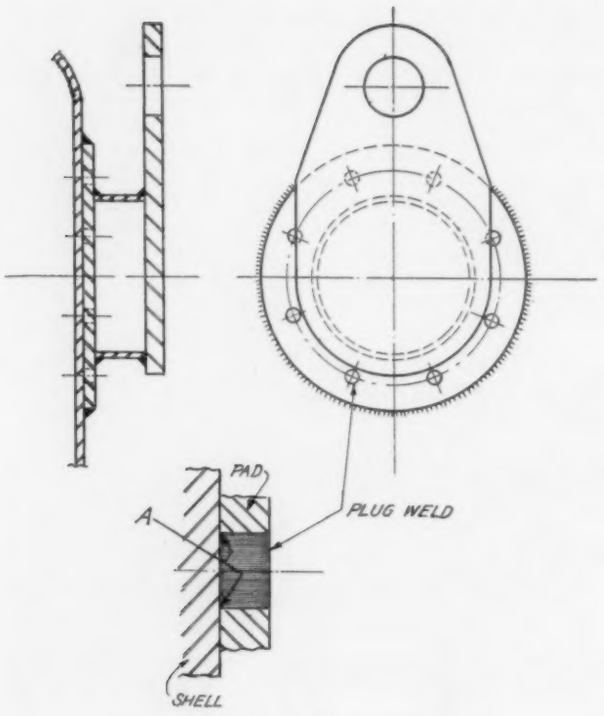


Fig. 3

possible to weld inside. One objection, made to the writer, seems not to be justified—namely, that highly corrosive substances will attack the inside protruding neck quicker than the remainder of the wall, thus removing the reinforcement. The corrosive progress will cover a certain thickness of exposed surface in proportion with time, thus weakening the inside shell just the same as the attachment joint.

Reinforcing rings have not only to be cut, they have to match the curvature of the shell or of the head. This requires some forging and fitting, unnecessary in mode *C* attachment, Fig. 1. They necessitate considerably more welding work. The ring is mostly beveled inside toward the neck, in order to obtain good penetration (*A*). Even when using the simplest connection (*B*), there is still one more fillet in comparison with *C*, namely, that outside of the ring.

Except where the strength computation shows clearly that the above way does not furnish sufficient material to replace the cutout, reinforcing rings are an unnecessary expenditure. Their general use seems to be a remainder of the habits in riveted construction. Here it was impossible to gain additional strength from an inside extending and reliably attached neck in such a simple way as in welding.

Summarizing: Complying with the codes, mode *C* saves plate stock and welding rod as well as cutting, fitting and welding work. It might, applied on a large scale, help in economy and in speeding up production.

Attachments Near Welded Joints

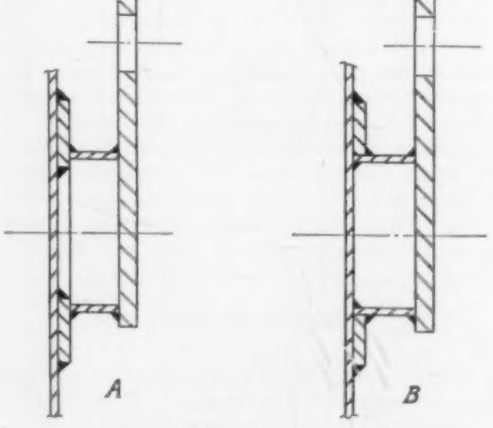
Four supporting lugs had to be attached to a tank. In attaching the pad, serving as a base for the extending brackets, to the shell, the designer took care to break the fillet welds on each side of the girth seam for a length of at least $2t$; (t, thickness of the shell) thus complying with Par. W 314-c of the A.P.I. Code, which says: "Nozzles shall be located with respect to girth joints attaching the head so that the distance from the edge of the attachment weld to the edge of the girth joint weld shall be at least 2 times the shell thickness...." It seems to be logical to apply the same principle as to nozzles to such structural attachments as lugs.

However, a study of the thermal action seems to render the whole paragraph questionable. Any weld, like the girth seam, sets up a greater or smaller amount of residual stresses in the weld and in its surroundings. Due to the cooling of the weld and its shrinkage, the restraint in the cool vessel wall creates tension stresses symmetrical and transverse to the welding direction (as well as stresses in the direction of welding). If the fillet weld attaching the pad is broken (Fig. 2 (*a*)), the shrinkage of that fillet creates a tensile stress in the surface of the vessel wall, which, however small, adds to the residual stress inherent in the wall from welding the girth seam, increasing a tendency to open up that seam.

On the other hand, if the fillet is carried through without any break, the whole fillet will tend to shrink toward its center now coinciding with the location of the girth seam (this location has been chosen intentionally with regard to the following conclusion concerning nozzles). The slight surface stresses in the adjacent shell have now the opposite direction than before (Fig. 2 (*b*)). Instead of adding to the residual stress they counteract it, which is definitely desirable.

Considering the small length of girth seam engaged and the rather negligible amount of stresses created, the whole discussion may appear purely theoretical. However, it shows that "staying away from the seam" is not necessarily the best way to save trouble. And it may open the question whether a nozzle, placed with its center right in a welded joint, is not better than one with the edge of its weld one inch apart from it, as Par. W 314-b of the A.P.I. Code requires.

Fig. 4



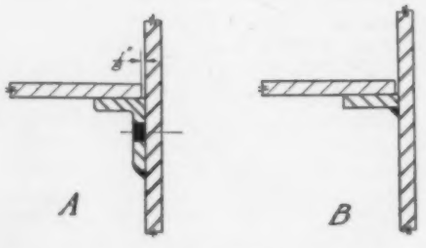


Fig. 5

Uncertainty is prevalent among designers, whether or not one is allowed to weld across a welded seam. A design may carefully break lug welds at the girth seam, as mentioned before, and may have a continuous circumferential fillet weld inside the vessel, connecting the tray plates with the shell, which naturally runs across the longitudinal shell seam. If welded intersections of that kind have to be avoided at all, because they may reduce the strength of the shell seam, then the longitudinal shell joint is certainly more prone to such an adverse effect than the girth joint. It is the writer's opinion that crossings of that sort can safely be made (and are made in many shops) after grinding smooth the shell seams at the locations where the welds meet.

Plug Welds

A good deal of emphasis has been given to the necessity that designers for welding should shake off design habits derived from riveted and bolted construction, and work out details for fully developing all the advantages inherent in flame cutting and welding. Nevertheless, often enough unconsciously designers are compromising by applying constructions of the riveted kind, merely replacing rivets by plug welds. Figure 3A shows as an example a lifting lug attached to a tower. Plug welds have been used in order to prevent the circular pad *a*, attached by an all-around fillet to the shell, from lifting at its inner section from the shell under the bending stress arising during the erection of the tower. The area bound by plug welds is relatively small as compared to the large unbound area in this case. The strength of the plug welds depends mainly on whether the basic edge "A" can reliably be brought to fusion at the start of the weld. Incomplete fusion is liable to occur when the hole is so small that the arc tends to flutter around toward other spots than the edge where it has to be concentrated. Such incomplete fusion just at that location where a concentration of the shear and bending stresses occurs at any rate, may easily become the starting center for notch cracking under load. Every cracked plug weld may put its neighbor welds under increased load.

Two ways are shown in Fig. 4 how the same lug can be attached in a more reliable and economical way. In Fig. 4A a hole somewhat smaller than the inside diameter of the tubular section *b* is burned in the pad and a circular fillet weld connects the inside edge of the pad to the shell. As an alternative, the tubular part is brought down and fillet welded to the shell (Fig. 4B). In both cases the cutout in the pad does not reduce the moment of inertia of the section at any appreciable amount.

A cast-iron tray plate had to be supported along the shell of a tower leaving a clearance of only $^1/_8$ in. between plate edge and vessel wall (Fig. 5A). A detail made for that purpose shows an angle *b* attached to the shell by a circumferential fillet weld at the lower end of its vertical leg. In order to relieve that fillet weld from too high a bending stress under load, a row of plug welds is placed between the upper part of the vertical leg and the shell.

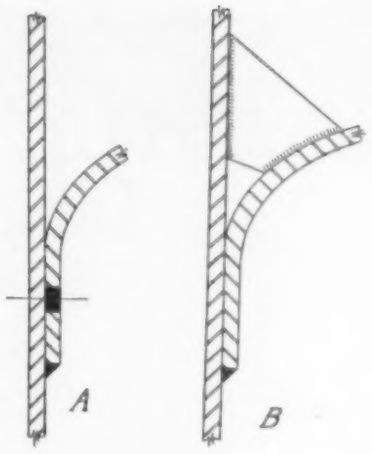


Fig. 6

Quite obviously the designer is still thinking in terms of riveted construction, where angles had to be used for every corner connection. He contents himself by merely replacing rivets by plug welds.

An adequate welded detail is shown in Fig. 5B, obtaining a satisfactory result with a fillet-welded bent bar or strip cut from plate.

It should not be doubted that the first described detail may serve its purpose; but, when (as it actually happens) its application becomes standard for a large number of vessels, it can hardly be considered as a good interpretation of welded design.

A flanged and dished head had to be placed with its convex side toward the inside of a storage tank, 10 ft. in diameter. The design called for 52 plug welds 1 in. diam. (Fig. 6A) and 6 in. on centers between the straight flange of the head and the shell, relieving the fillet at the edge of the head flange from carrying the whole strain under load. Before plug welding, the 52 holes had to be drilled in the head flange. A number of gussets, flame cut from scrap plate and welded to shell and head (Fig. 6B) would probably offer a better solution, combining greater strength with easier, faster and cheaper fabrication. The few continuous fillets will require much less time than the making of 52 plug welds.

Summary

The purpose of these examples has been to recommend a liberal interpretation of the design rules for welded pressure vessels given by the codes, as long as the necessary safety in construction can be maintained. Furthermore, some examples for welded details are given in order to induce designers to free themselves of certain habits derived from riveted construction which prevent a full utilization of the advantages given in the simplicity and economy possible in welded design.

Speed-Up Arc Welding—Use Larger Electrodes

By H. O. Westendarp, Jr.*

THE arc-welding process has demonstrated its effectiveness in speeding up the production of ships, tanks, guns and innumerable other products urgently needed in large volume for the war program. The problem now is to speed up arc welding; the problem of more work with less men must be solved.

The answer is—on those applications where work conditions permit, use larger diameter electrodes which have a faster deposition rate in pounds per hour. Many jobs are being welded today with $^5/_{32}$-in. or $^3/_{16}$-in. diameter electrode where a larger diameter electrode could be used to produce welds just as high in quality and at a decided increase in speed.

Military requirements are draining our manpower needed for production work. Arc welding is a process which requires highly specialized training, which takes time (approximately four months). Based upon present estimates of 200,000 arc-welding operators in the industry, a study of the following data will indicate that if these operators could swing to larger electrodes on one-quarter of their work the result would be equivalent to an immediate addition of from 15,000 to 25,000 experienced operators to the welding industry.

Using larger electrodes for increased speed is not a new idea; it has frequently been advocated by welding engineers and some progressive plants are now operating on this basis. Under today's conditions, however, it is of the utmost importance that this matter be investigated thoroughly by all users of welding. In such investigations a careful analysis should be made to determine:

1. The general classes of arc welding where this "speed-up" may most effectively be accomplished.
2. The specific applications in these classes where work conditions permit larger electrodes to be used.

The following considerations will serve as a guide in changing successfully from smaller to larger electrodes.

* Welding Engineer, General Electric Company.

Fig. 1—Steel Machine Base Being Welded with $^5/_{16}$-In. Electrode in Flat Position

Position of Welding

A $^3/_{16}$-in. diameter electrode is the largest size with which it is practical to weld in the vertical and overhead position. Larger electrodes require amperages which produce too much heat for proper control of metal in vertical and overhead welds; as a result spatter loss is excessive, and poor welding results.

Fillet Size

An increase from $^5/_{32}$-in. diameter to $^3/_{16}$-in. diameter electrode is not recommended for vertical fillet welds until the size of the fillet reaches $^5/_{16}$ in. or greater. A $^5/_{32}$-in. diameter electrode is preferred for making $^1/_4$-in. and smaller fillet welds in the vertical position. A $^3/_{16}$-in. diameter electrode applied to these smaller size fillet welds results in surplus weld metal being deposited in the form of a convex bulge on the fillet which would not contribute to strength and would waste scarce electrode material.

Plate Thickness

Many applications are such that the work either is or can be successfully positioned for flat welding. In this, as in the vertical and overhead position, plate thickness will affect the maximum size electrodes that can be regarded as practical to use. Generally speaking, electrode diameters up to the plate thickness can be used. This is affected, however, by other conditions, such as fit-up, type of joints, etc. Electrodes are available in sizes up to $^3/_8$ in. diameter. Larger sizes have not proved to be practical to date.

Table 1 shows the "speed-up" possible in those cases where work conditions permit change to larger electrodes.

Fig. 2

Fig. 3

Comparative Production Data of Above Welds

	Left	Right
Time	1 Minute	1 Minute
Size Fillet	1/4 In.	1/4 In.
Size Electrode	3/16 In.	1/4 In.
Length Fillet	5.75 In.	10 In.

Table 1—Typical Deposition Rate, Pounds Per Hour—100% Arc Time

Electrode Diam., In.	Flat*	Horizontal*	Vertical*	Type of Electrode	
5/32	2.9	2.7	2.4	All-position d.c.	Reverse polarity
3/16	4.5	4.0	3.2	All-position d.c.	Reverse polarity
1/4	8.0	6.0	...	Flat a.c. or d.c.	Straight polarity
5/16	11.5	...	...	Flat a.c. or d.c.	Straight polarity
3/8	13.5	...	...	Flat a.c. or d.c.	Straight polarity

* Current at proper value in all cases.

Table 2 shows rather startling increases in speed when considered on a percentage basis:

Table 2

Position of Welding	Change in Electrode Size	Increase in Deposition Rate, %
Vertical and overhead	5/32–3/16	33
Horizontal	3/16–1/4	50
Flat	3/16–1/4	77
Flat	1/4–5/16	43
Flat	5/16–3/8*	18

* Experience indicates that magnetic arc blow increases with the size of electrode and welding current. Therefore the 3/8-in. diameter electrode is generally recommended for operation with alternating current only.

In addition to the above savings which are based on the difference in deposition rates of electrodes, larger electrodes reduce the number of times the operator has to stop welding and change electrodes. Time required for cleaning the crater and restriking the arc is also reduced. The number of changes required per pound of metal deposited for various size electrodes are shown in Table 3.

Table 3

Electrode Size	Electrode Changes per Pound Deposited
5/32 x 14 in. length	18
3/16 x 14 in. length	13
1/4 x 18 in. length	5
5/16 x 18 in. length	3
3/8 x 18 in. length	2

The following will indicate the major classes of arc-welding applications and their corresponding electrode requirements, and will indicate where pressure should be applied in order to speed up production.

Major Classifications

1. *Field welding:* Ships, buildings, bridges, pipe lines, etc. Approximate electrode requirements—85% all-position type, 15% flat type.
2. *Shop welding:* General fabrication, tanks, gun mounts, ship sub-assembly work, machinery, etc. Approximately 65% flat type, 35% all-position type.
3. *Shop welding:* Repetitive straight line production welding operations—axle housings, tank wheels, etc. One hundred per cent flat type or 100% all-position type.
4. *Job shop welding:* Miscellaneous small parts. Approximately 75% all-position type, 25% flat type.

Attention should be directed to Classes 1 and 2. They offer the greatest opportunity for "speed-up." Class 3 has already received detailed time study, and in practically all plants the most economical electrode is now being used. For example, a tank wheel fabrication job would be carefully studied to determine the best type of electrode from the standpoint of physical properties of deposit, weldability characteristics, speed, etc. Then the type selected would be used by the entire production line.

Class 4 represents a very small percentage of the industry and the use of larger electrodes is limited by plate thickness and type of work.

Applications in Class 1 should be studied to determine ways and means of increasing from 5/32 to 3/16-in. all-position type electrodes wherever work conditions permit.

Applications in Class 2 should be studied primarily to determine ways and means of increasing from 3/16-in. all-position type to 1/4-in. horizontal type electrodes, where work conditions permit. This class also includes opportunity for increasing from 3/16 on up to 3/8-in. flat type electrodes where work conditions permit.

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Design of Lap-Welded Continuous Beams

By Adolph Barjansky*

THE conservation of national resources is so important now that all methods promising a more economical use of engineering materials deserve careful investigation. In an article (Ref. 1) published some time ago in THE WELDING JOURNAL, A. Amirikian proposes a new method of splicing continuous purlins by lapping, as shown in Fig. 1. The reference is extremely brief and no quantitative data are included, except figures on weight reduction and an approximate length for the overlapping, which is given as 10% of the span.

In the present paper an attempt is made to clarify the design of this type of continuous member under certain simplifying assumptions frequently found in practice: (1) the load is uniformly distributed throughout; (2) the spans are of equal length; (3) the cross section is the same in all spans.

The potential savings of the method to be described can best be realized by the following example: to design a five-span beam, each span being 20 ft. long and loaded with 500 lb. per ft. The procedure can be arranged as follows:

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	Simple Beams	Butt-Welded Continuous Beams	Lap-Welded Continuous Beams
Design moment	$0.125\ wl^2$ = 25 K-ft.	$0.105\ wl^2$ = 21 K-ft.	$0.077\ wl^2$ = 15.4 K-ft. (from Table 2)
Channel required (Carnegie Handbook)	10 in. at 25 lb./ft.	10 in. at 20 lb./ft.	9 in. at 13.4 lb./ft.
Total weight	2.5 kips	2.0 kips	1.41 kips
Percentage	100%	80%	56%

This shows that in this case, the design to be presented below allows an economy of 44% as compared to a simple beam design and 30% relatively to a non-lapped continuous construction.

Passing now to design details, the length of overlapping necessary in a beam with given moment diagram will be determined.

Length of Overlappings.—Under normal conditions

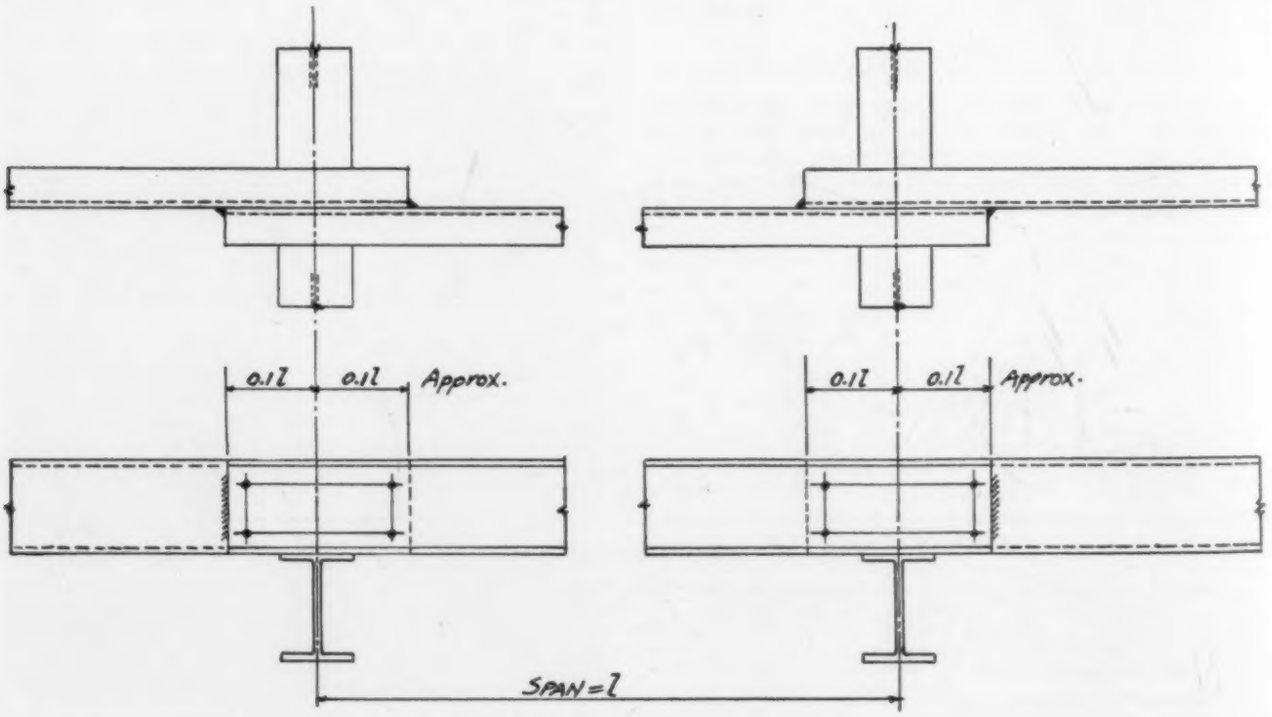

Fig. 1

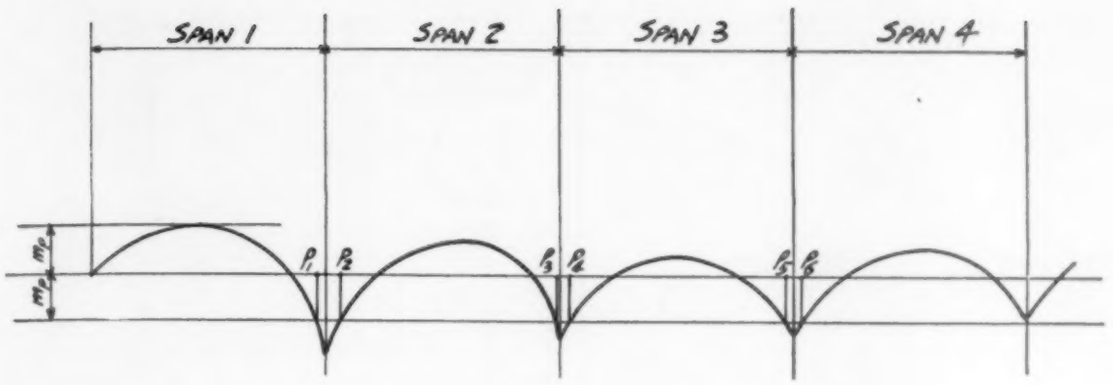

Fig. 2

uniform loading produces a parabolic moment diagram in each span, the negative moment at support 12 (between spans 1 and 2) being the highest moment for the whole beam. In the design of a continuous beam of a single section, this largest negative moment must therefore determine the section modulus required. For a lap-welded beam, however, the section modulus at the support is doubled, so that the maximum stress occurs elsewhere.

Referring to Fig. 2, it is evident that in span 1 lapping need not extend beyond point P_1, at which the moment has the same absolute value as the maximum positive value m_p on the first span. Similarly, on the other spans lapping is useless beyond points P_2, P_3, etc., at which the negative moments have the value m_p. This is so because the maximum positive moments on the interior spans are always smaller than m_p. With lapping arranged as shown in Fig. 2, the section modulus of the beam is now selected to withstand the "principal moment," m_p.

If $-m_1$ and $-m_2$ are the moments at the two end-supports of a unit-length beam with unit continuous loading, the moment at any point x of this beam is given by:

$$m_x = -m_1 + (1/2 + m_1 - m_2)x - \frac{x^2}{2}$$

The abscissas of the points at which the moment is equal to $-m_p$ are given by the relation:

$$m_x = -m_p \qquad -m_1 + (1/2 + m_1 - m_2)x - \frac{x^2}{2} = -m_p$$

or

$$\frac{x^2}{2} - (1/2 + m_1 - m_2)x + m_1 - m_p = 0$$

the roots are:

$$a' = 1/2 + m_1 - m_2 - \sqrt{(1/2 + m_1 - m_2)^2 - 2(m_1 - m_p)}$$

$$b' = 1/2 + m_1 - m_2 + \sqrt{(1/2 + m_1 - m_2)^2 - 2(m_1 - m_p)}$$

as shown in Fig. 3. The lengths a' and b' give theoretical values of overlapping, and actual reinforcement should be somewhat larger; this increase was arbitrarily selected as 10%, so that the real values used in this paper were not a' and b', but a and b, defined as $a = 1.1a'$ and $1 - b = 1.1(1 - b')$ or $b = 1.1b' - 0.1$. This relatively low increase over the theoretical value is due to the fact that no additional length of overlapping is necessary in the construction suggested in Ref. 1 since, as shown in Fig. 1, the full strength of the weld is present at the

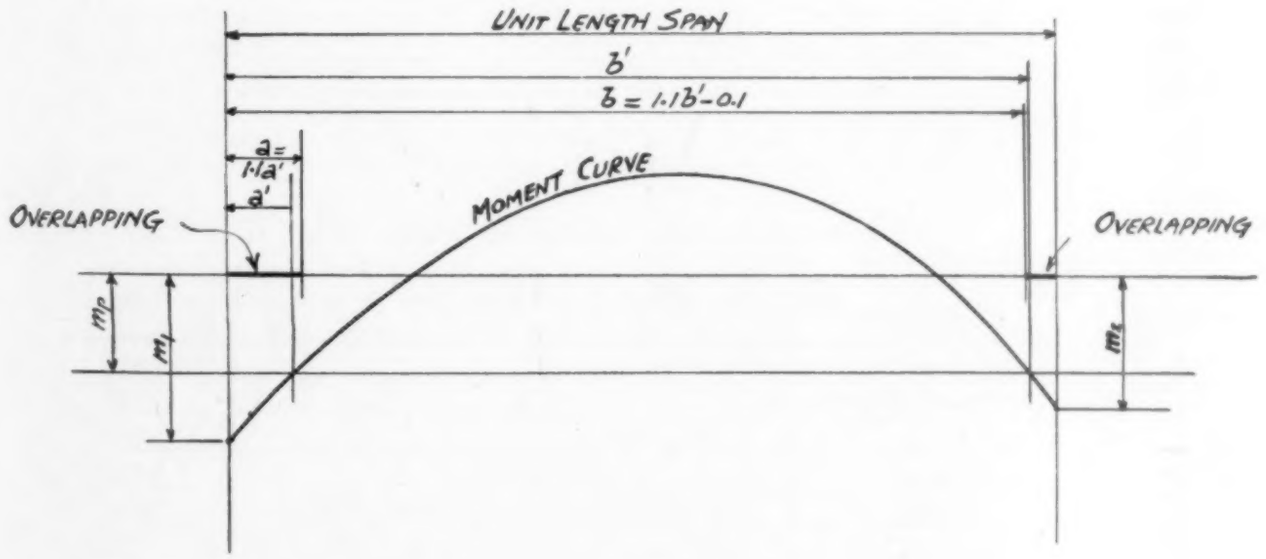

Fig. 3

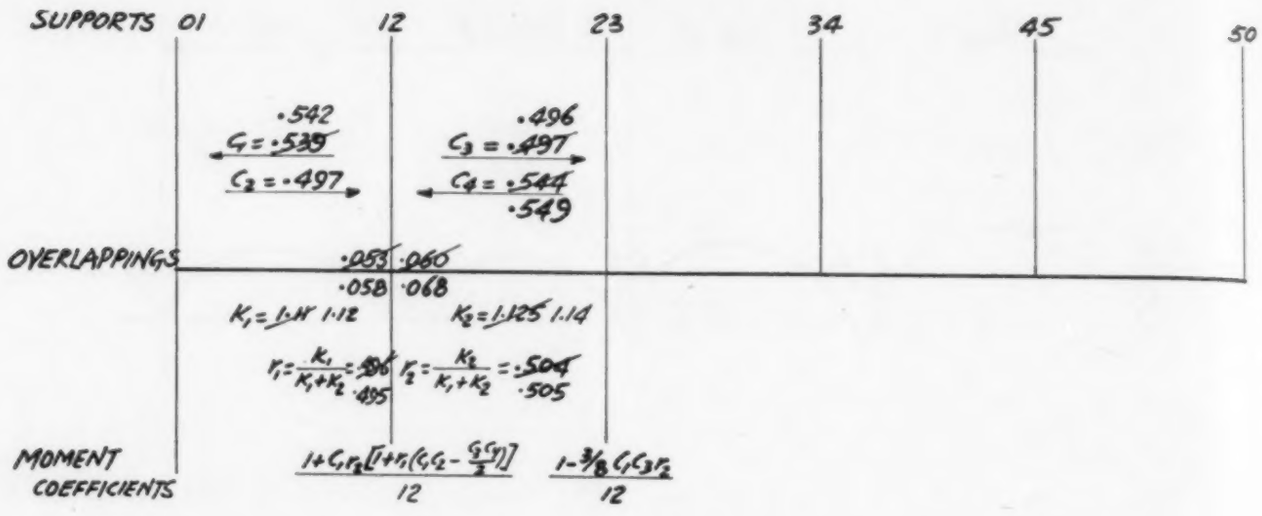

Fig. 4

welded section itself, and needs no developing. The final values become:

$$a = 1.1\ [1/2 + m_1 - m_2 - \sqrt{(1/2 + m_1 - m_2)^2 - 2\ (m_1 - m_p)}] \quad (1)$$

$$b = 1.1\ [1/2 + m_1 - m_2 + \sqrt{(1/2 + m_1 - m_2)^2 - 2(m_1 - m_p)}] - 0.1 \quad (2)$$

Equations (1) and (2) represent the general case shown in Fig. 3. A few special cases can be treated here to facilitate applications.

For the first span, $m_1 = 0$ and $m_p = 1/2\ (1/2 - m_2)^2$. Substituting into (1) and (2), a assumes a negative value, as could be expected, while b becomes $1.1(1/2 - m_2)(1 + \sqrt{2}) - 0.1$ or

$$b = 1.228 - 2.656\ m_2 \quad (3)$$

In a symmetrical beam, such as the middle span when the total number of spans is odd $a = 1 - b$, $m_1 = m_2$ and

$$a = 1.1\ [1/2 - \sqrt{1/4 - 2(m_1 - m_p)}] \quad (4)$$

$$b = 1.1[1/2 + \sqrt{1/4 - 2(m_1 - m_p)}] - 0.1 \quad (5)$$

The expressions reached in the above paragraphs were used to construct Table I, which gives the values of the overlappings and of the m_p's for beams with different numbers of spans. These values are based on m_1's and m_2's as tabulated in handbooks, i.e., on the three-moment equation. One objection which arises at this juncture is the following: Since the elastic properties of lapped spans are evidently different from those of spans with constant moment of inertia, will not the resulting values of m_1 and m_2 sufficiently depart from the handbook values to affect the length of overlapping required? To answer this question, it is necessary to establish the moment diagram of a continuous beam with overlappings.

Effect of Overlappings on Moment Diagram.—Any of the standard methods used to solve indeterminate structures could in principle be applied to this problem, but moment distribution was finally selected as the least cumbersome. The distribution of moments in special beams such as those considered here necessitates the knowledge of three factors, the "fixed-end moment," F, the "carry-over" factor, C, and the "distribution" factor, K. These factors are defined in most modern texts on indeterminate structures (see for instance, Ref. 2).

The method of computing the values of F, C and K, as well as curves from which they can easily be obtained for any overlapping, may be found in a short note by the present writer (Ref. 3).

Application to Five-Span Beam.—The procedure is illustrated in Fig. 4. Tentative overlappings are taken from Table 1 and used to find the different values of F, C and K from the curves of Ref. 3. These values are introduced into the expressions denoted as moment coefficients in Fig. 4 and a value of 0.108 found for the moment at support 12, and 0.079 at 23. Substituting into equations (1), (2) and (3), a second set of overlappings is com-

Table 1—Overlappings from Three-Moment Eq.

SUPPORTS / No OF SPANS	12		23		34		45		56		67		m_p
	LEFT	RIGHT	L	R	L	R	L	R	L	R	L	R	
2	·106	·106											·0703
3	·038	·046	·046	·038									·080
4	·057	·065	0	0	·065	·057							·0772
5	·053	·060	0	0	0	0	·060	·053					·0779
6	·054	·062	0	0	·019	·019	0	0	·062	·054			·0777
7	·054	·062	0	0	·015	·015	·015	·015	0	0	·062	·054	·0778
∞	·054	·062	0	0	·016	·015	·011	·011	·012 → EVERYWHERE				·0778

Table 2—Overlappings Corrected for Elastic Differences

No. OF SPANS \ SUPPORTS	12		23		34		45		56		67		m_p
	LEFT	RIGHT	L	R	L	R	L	R	L	R	L	R	
2	·114	·114											·069
3	·043	·053	·053	·043									·079
4	·061	·073	0	0	·073	·061							·076
5	·058	·068	0	0	0	0	·068	·058					·077
6	·060	·070	0	0	·021	·021	0	0	·070	·060			·077
7	·060	·070	0	0	·016	·016	·016	·016	0	0	·070	·060	·077
∞	·060	·070	0	0	·018	·016	·012	·012	·013 —— EVERYWHERE				·077

puted, new F's, C's and K's read off the curves of Ref. 3, and the moment coefficients recalculated. These are found to be so close to the first values that the process can be stopped and the second series of overlappings accepted as final.

The same quickly converging method of successive approximations was carried out for beams of different numbers of spans, and the results collected in Table 2, which shows overlappings corrected for elastic effects, as well as the resulting values of m_p. It is perhaps interesting to note here that the departure of F from the non-overlapped value of $^1/_{12}$ becomes quickly negligible as the number of spans increases, so that for four spans already $F = {}^1/_{12}$ gives results accurate to 1–2%. The application of Table 2 was shown in the example at the beginning of the present article.

Acknowledgment

The writer wishes to thank Professor Milo S. Ketchum of the Case School of Applied Science, who brought the problem to his attention, helped considerably in its solution, and read the first draft of the manuscript.

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(*Continued on page 412*)

Welding Oil Machinery and Equipment

By A. F. Davis*

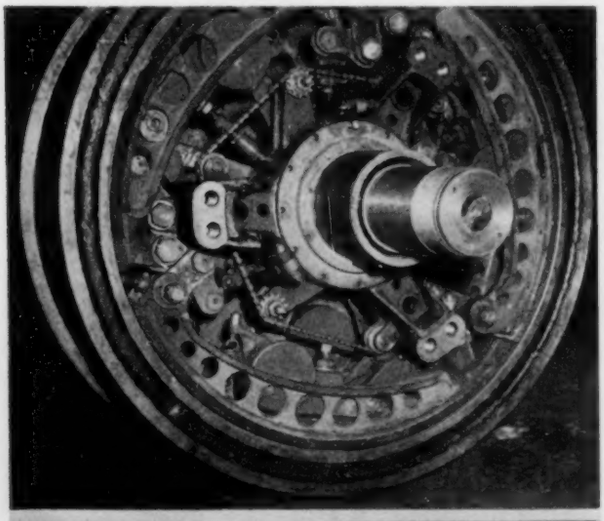
Texas Manufacturer Finds Arc Welding Speeds Fabrication of Oil-Field Machinery

ENGINEERS for the Wilson Manufacturing Company, Inc., Wichita Falls, Tex., find that application of the modern shielded arc-welding process saves time, money and weight in the fabrication of rigs and winches for oil wells.

An interesting recent development in welded design is the water-cooled friction clutch shown in Figs. 1 and 2.

* Vice-President, Lincoln Electric Co., Cleveland, Ohio.

Fig. 1—Water-Cooled Clutch for Use on Rigs in the Oil Fields. Note the Divided Hole in the Main Shaft Used to Circulate the Cooling Water



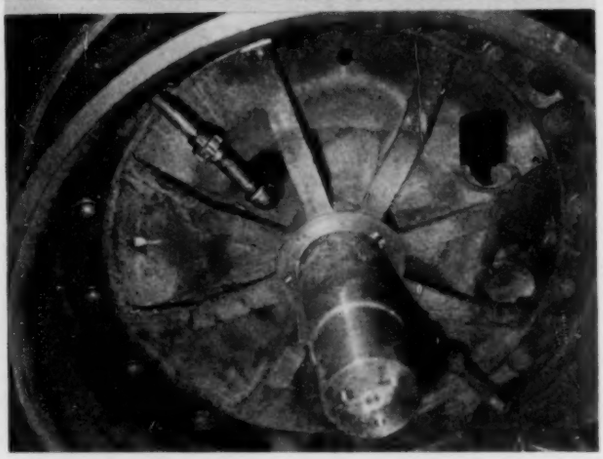


Fig. 2—View of the Other Side of the Arc-Welded Clutch. This Photograph Shows Also the Pipes Used to Conduct the Water to and from the Clutch Ring

Fig. 3—Brake Ring and Water-Cooled Chamber Assembled and Positioned on a Jig for Down-Hand Welding

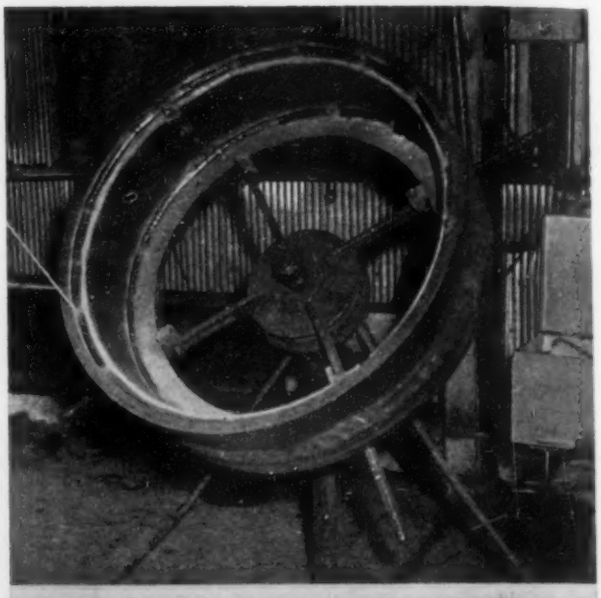


Fig. 4—This Picture Shows a Welder at Work on a Seam of the Water-Cooled Chamber

This device employs considerable rolled steel. This factor, plus the water-cooled design and the fact that arc welding was used to fasten the component parts, gives the clutch an exceptionally long life.

Water is circulated in the space between the brake ring and the clutch ring, with the outer water introduced into this space through the main shaft, as shown in Fig. 1. As may be seen from this illustration, this shaft opening is divided into two halves, one serving as the inlet and the other as the outlet. Pipe connections carry the water to and from the openings to the space between the brake and clutch rings.

The brake ring and the water-cooled chamber are made from arc-welded high-tensile steel and are shown in Figs. 3 and 4. Figure 3 shows the assembly positioned for downhand welding of the cooling chamber plate to the brake ring. This picture also shows a good view of two of the arc-welded seams, illustrating the type of smooth, strong welds which may be obtained with modern shielded arc equipment.

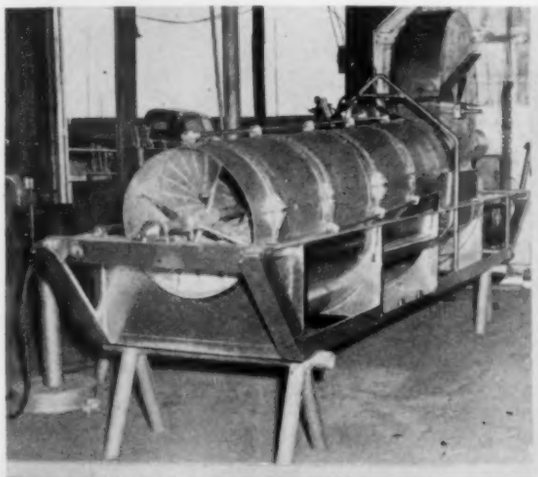
A welder may be seen in Fig. 4 completing a seam on the water-cooled chamber of the clutch. Downhand welding is used again here and the device is held in place by special clamps.

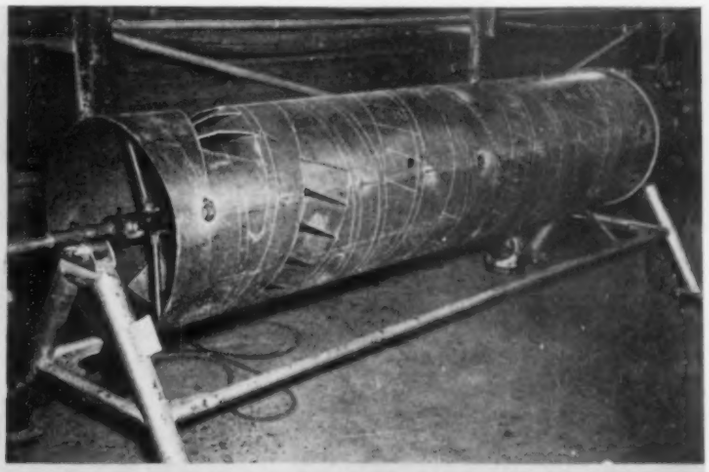
Arc Welding Finds Unique Applications in Fabrication of Oil Field Equipment

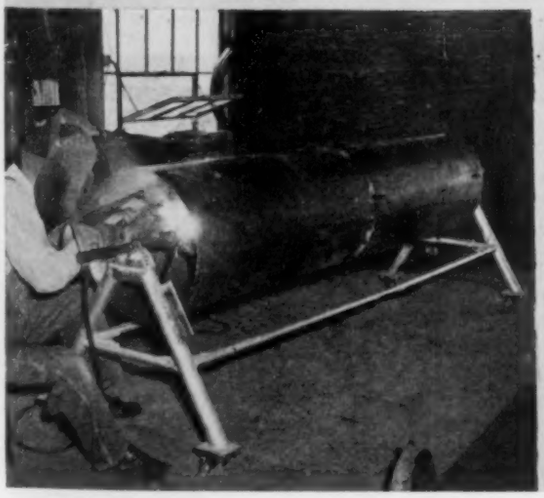
THE use of the arc-welding process in the fabrication of equipment for oil field use is increasing rapidly with the demand for more oil for the war effort and the increasing recognition of the arc process as a "speed-up" method of construction.

A particularly ingenious application of arc welding is being used by the Thompson Tool Company, Inc., of Iowa Park, Texas, in the construction of the shale separator drum shown complete and installed in Fig. 5.

These drums are used in the production of combination shale separators and sampling machines designed to receive the mud from a well being drilled and to condition the mud so as to reduce wear on pump parts before the mud is pumped back into the well. This, it is believed, lessens the dangers of cave-ins by enabling the walls of the well to stand up better. It also reduces the possibility of stuck drillpipes which sometimes result in "fishing" jobs. These machines also eliminate the need for large slush and reserve pits sometimes used to allow the shale to settle out of the mud. The sampling ma-







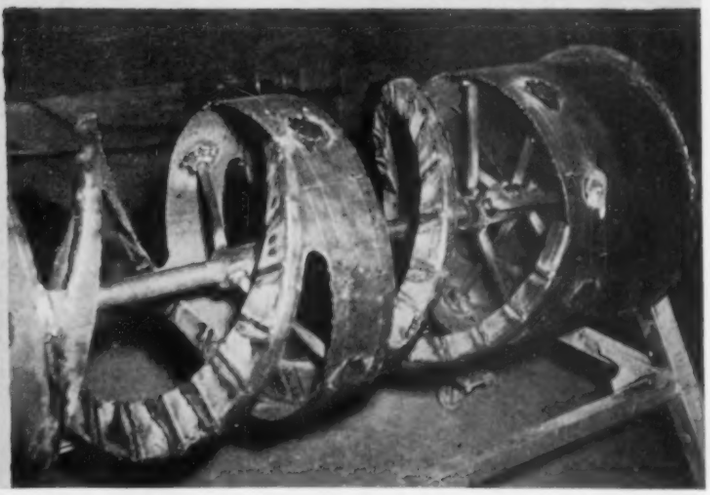
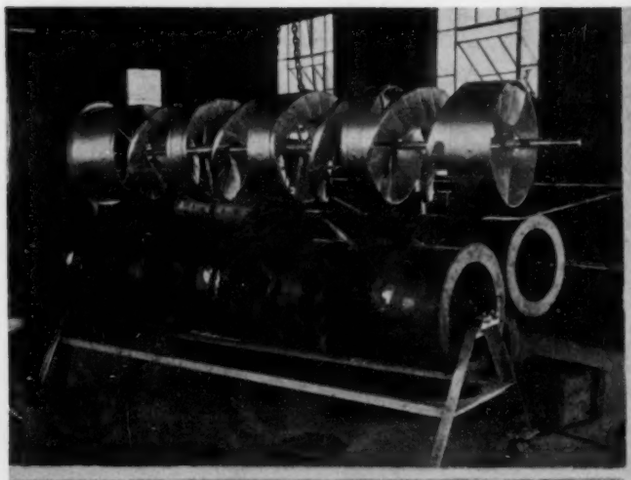
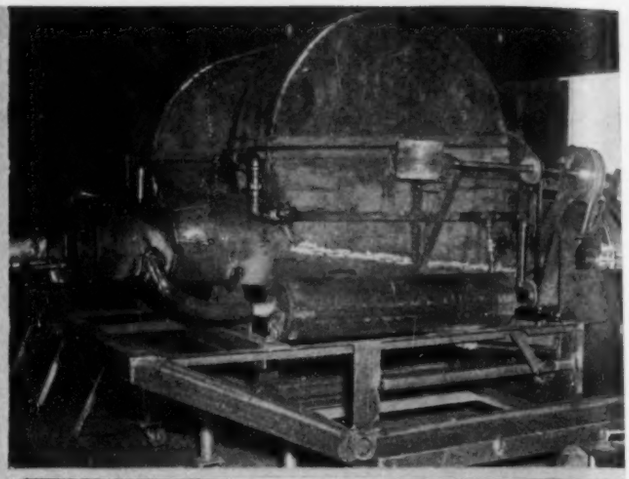
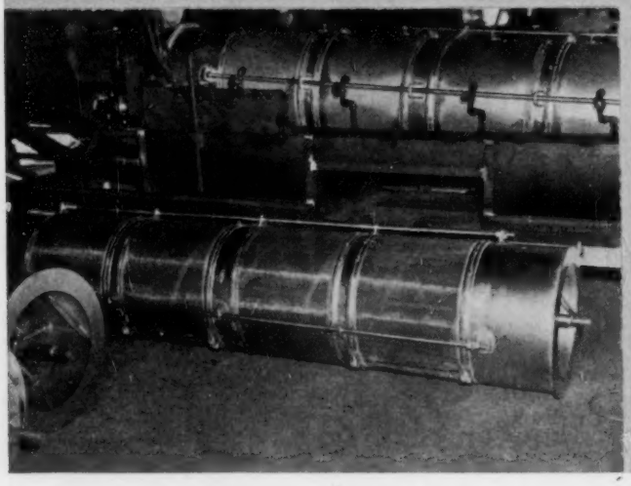


Fig. 5 (Top)—Completed Shale Separator and Sampler Machine of Arc-Welded Construction
Fig. 6 (Bottom)—Welder at Work on the First Step in the Fabrication of the Shell Separator Drum

Fig. 7 (Top)—This Picture Shows Part of the Flame Cutting of the Vanes Completed
Fig. 8 (Bottom)—Vanes Completely Flame Cut and Welded by Means of the Electric Arc







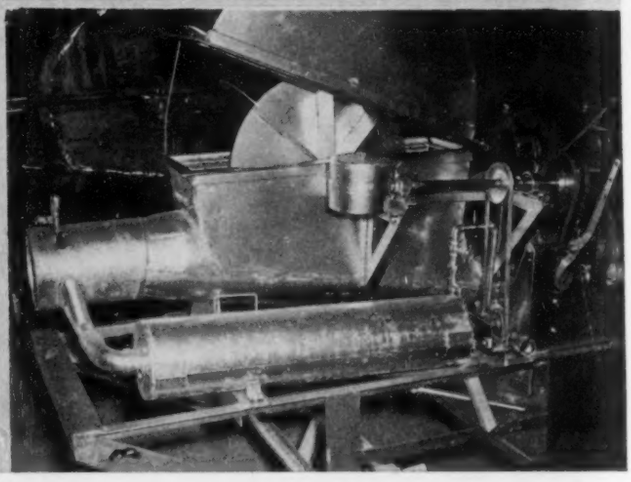


Fig. 9 (Top)—Three Completed Drums Are Shown Here. One Has Been Painted and the Others Are About to Receive This Treatment
Fig. 10 (Bottom)—Drum, Screened and Ready for Installation

Fig. 11 (Top)—Power Wheel End of a Fairly Large Machine
Fig. 12 (Bottom)—This Power End View of a Completed Machine Shows the Paddle Vanes of the Power Wheel

chine built into these separators provides an accurate sample of the formations which are drilled.

An unusual feature of this all-welded machine is its screen drum which is cut and welded from a solid cylinder of welded plate. This drum provides an extremely rigid, one-piece construction and makes possible smooth operation and gives long life to the device.

The first operation in the construction of the shale separator drum is shown in Fig. 6. Two rolled steel plates 4 ft. long are rolled into cylinders of 20 in. diam., and are welded end to end to make a cylinder 8 ft. long, in this particular design. The cylinders are supported by 24 steel spokes $^3/_4$ in. in diam. These are arc welded both to the cylinder and to the five hubs on the bearing shaft, thus forming a rigid one-piece construction. In the preliminary stage shown in this picture, the spokes are merely inserted in holes through the cylinder walls and are bolted in place. The remainder of the spokes are added and are welded after the cylinder walls have been cut as shown in Fig. 7.

This latter illustration shows a portion of one of the cylinders after the cylinder walls have been partially flame-cut. The width of the vanes varies, with the narrow vanes near the inlet end. All of this variation must be taken into consideration in the layout of the cylinder for cutting. Figure 8 shows one of the drums after this flame-cutting has been completed and the vanes turned down and securely arc welded. The construction of the hubs and spokes may also be seen clearly in this photograph.

The drums, completely welded, are shown in Fig. 9. Two of these drums, all of which are made from 10-gage plate, are shown unpainted, while the uppermost drum is illustrated as it dries after painting.

The next step is the screening of the drums to achieve the result shown in Fig. 10. The screen, applied to the outside of the drum, is made of Monel metal so as to resist corrosion from water with acid characteristics.

The mesh of this screen determines the consistency of the mud to be used. The shale which does not pass through the screen passes out of the lower end of the drum, while the mud is returned through the pump to the well.

Figure 11 shows the power wheel end of a fairly large size machine. The sampler is the small cylinder in the foreground.

The inside construction of a power wheel and other details at that end of the machine may be seen in Fig. 12.

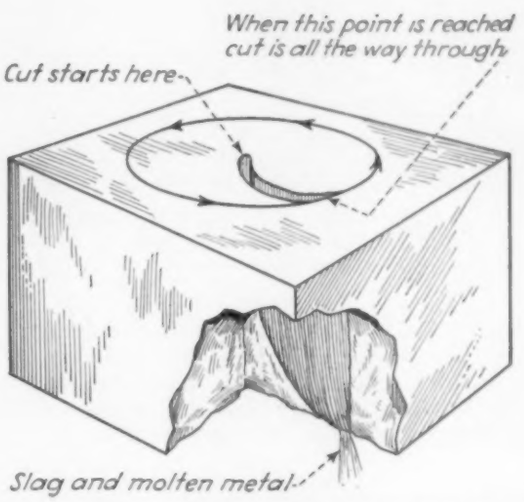
The other, or output, end of a completed machine may be seen in Fig. 5.

The entire machine is mounted on a welded steel skid frame made from welded angle sections. All moving parts are mounted on ball bearings. The machine is powered solely by the mid flow, which reacts on the web type of power wheel with curved plates (see Fig. 12). This wheel turns the drum through a gear and belt drive.

How to Cut Heavy Steel Sections

By R. B. Aitchison*

EVEN after considerable experience in cutting metals with the oxyacetylene blowpipe, it is still hard for many operators to realize that oxygen cutting is a chemical reaction and that the difficulty of cutting or time required is not at all proportional to the thickness of the metal. The oxyacetylene cutting operation is not one requiring mechanical force or great physical effort. When an operator first attempts to cut material much heavier than that to which he is accustomed, there is an almost universal tendency to use an unnecessarily high oxygen pressure, apparently on the theory that high pressure is necessary for heavy cutting. This mistake, which is a very natural one to make, is probably the most frequent cause of trouble when first attempting to cut heavy sections with the blowpipe. The oxyacetylene cutting process depends simply upon the chemical reaction between oxygen and red-hot iron or steel. Sufficient oxygen must be supplied to keep the reaction going properly, but an excess will interfere with the cutting action just as too much draft will blow out a fire.



When a Hole Is to Be Cut Through a Relatively Thick Section of Steel, the Cut Is Not Started All at Once. The Blowpipe Is Gradually Moved Forward So That by the Time It Has Progressed About 2 In. the Cut Will Have Penetrated All the Way Through

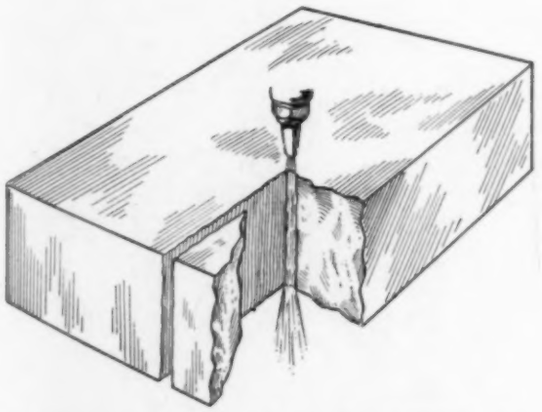
Importance of Correct Oxygen Pressure

When an oxygen pressure considerably in excess of that recommended by the blowpipe manufacturer is used in an attempt to cut a piece of steel, say 10 in. thick, the cut will start all right at the corner but soon it will be found that it is not penetrating all the way through the metal. After a while, the cut will stop altogether, and an examination will show a rounded cavity has been formed in the steel.

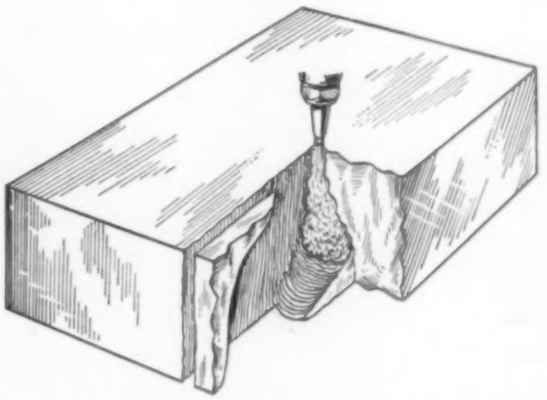
The cavity is not, as many have thought upon first sight, a blowhole in the metal, but has been formed entirely by the action of the extra amount of oxygen. The mixture of hot slag and metal in the cut is actually cooled by this excess oxygen so that cutting is slowed down. This causes a swirling action at the bottom of the cut which soon hollows out a cavity. If the oxygen pressure is not high enough actually to cause the cut to stop, but still too high for proper operation, the kerf will tend to flare out at the bottom, where it may be as much as an inch or more in width.

Reduction of the oxygen pressure to that recommended in the instruction sheet accompanying the blowpipe will result in a satisfactory cut. A smooth kerf about $^3/_8$ in. wide at the top tapering to about $^1/_4$ in. at the bottom can then be made. The secret of successful cutting of heavy material is to use the pressures rec-

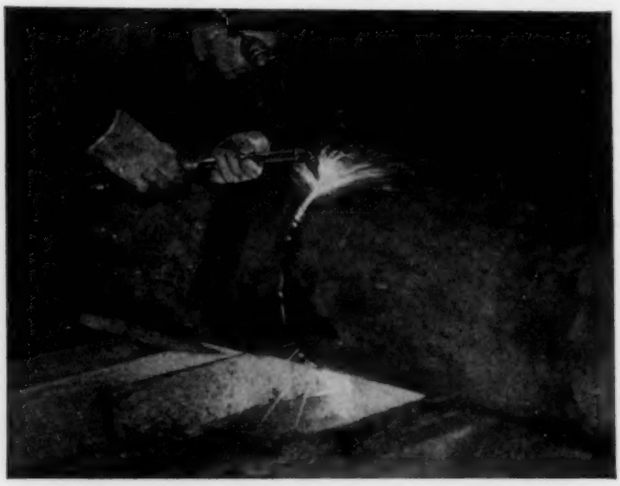
* The Linde Air Products Company, New York, N. Y.



Proper Oxygen Pressure and Cutting Speed Will Result in a Smooth Kerf About $^3/_8$ In. Wide at the Top, Tapering to About $^1/_4$ In. Wide at the Bottom



This Sketch Shows What Is Likely to Happen When Too High an Oxygen Pressure Is Used. The Swirling Action Which Results Actually Rounds Out a Cavity



This Huge Steel Shaft Was Severed with the Cutting Blowpipe in Only 16 Min. The Shaft Is 19 In. in Diam. and Weighs More Than 10 Tons

Cutting Machines Are Often Used in Heavy Scrapping Operations Here, a 25-Ton Steel Casting 20 In. in Thickness Is Being Reduced to Charging Box Size

ommended by the blowpipe manufacturer and to employ oxygen hose of ample capacity. Make certain that there are no restrictions of any kind in the oxygen system that might interfere with furnishing the proper amount of oxygen to the blowpipe.

Cutting Holes

In cutting holes in thick sections with the blowpipe, first mark the outline of the hole with chalk or a center punch. Hold the blowpipe at a point about $^1/_2$ in. inside the outlined area, so the cut will start in the section that is to be discarded. Heat the surface at this point almost to melting. Then gradually press down the cutting-oxygen lever and at the same time advance the blowpipe with the nozzle perpendicular to the surface, tracing a line about $^1/_2$ in. in from the finish line. Regulate the advance of the blowpipe and the rate at which the cutting valve lever is depressed so when the blowpipe has advanced about 2 in. the cut will have penetrated the entire thickness and the cutting valve will be open all the way. Then advance the blowpipe steadily along the finish line and end by cleaning off the narrow section near the point of starting.

To start a cut on a round bar or shaft, where there is no corner on which to begin, first make a deep nick with chisel and hammer or sledge. This will give a thin edge or corner on which the cut can be started easily.

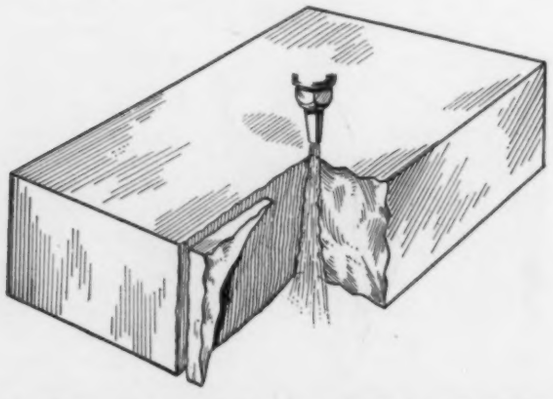
Heaviest Cuts

There is, of course, a limit to the thickness of metal that can be cut with the blowpipe alone. For the average skilled operator the limit is probably 18 or 20 in. More experienced operators are able to make even heavier cuts.

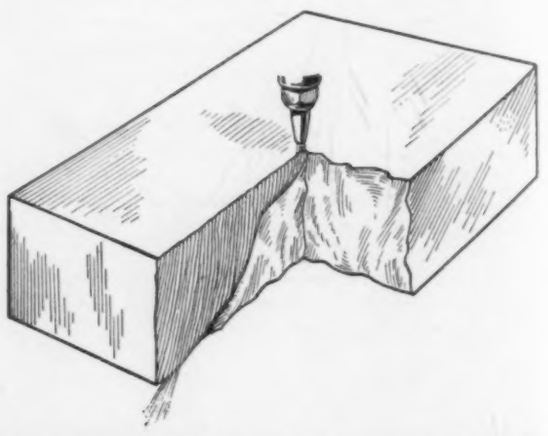
Steel and iron of practically unlimited thickness can be cut by means of a device known as an oxygen lance, used either alone or in conjunction with a cutting blowpipe. Masses of steel up to 8 ft. in thickness have been severed in this way.

The Oxygen Lance

An oxygen lance consists essentially of a length of steel pipe connected through an oxygen hose to a regulated supply of oxygen. In setting up an oxygen lance, at least two cylinders of oxygen should be connected by a properly designed manifold, and the flow of oxygen should be controlled by a manifold regulator that can pass the large volumes of oxygen required by the lance. For con-



If the Oxygen Pressure Is Not Quite So High as That Shown in the Previous Sketch or if the Cutting Speed Is Too Low, the Result Is Apt to Be Something Like That Shown Here



If the Cutting Speed Is Increased to Compensate for Too High an Oxygen Pressure the Effect Is as Shown Here. The Lag Frequently Causes Slag to Be Thrown Out at the Top

The Oxygen Lance Is of Utmost Value in Steel Mills for the Routine Cutting of Salamanders, Spills and Ladle Skulls as Shown Here

Here, the Oxygen Lance Is Being Used in Conjunction with the Cutting Blowpipe to Remove a 7-Ton Riser from a 9-Ton Steel Casting

necting the regulator to the lance, oxygen hose, preferably at least $^{3}/_{8}$-in. nominal size, should be used. Pneumatic hose or fittings for air tools should never be used as there is always the possibility that oil or grease may be present. A piece of 1-in. extra-heavy steel pipe about 3 ft. long should be bent 90° and then connected to the oxygen hose through a reducing coupling and standard oxygen hose connection. This pipe serves as a handle for the lance, permitting the operator to work at one side out of the direct line of sparks and slag produced in the operation.

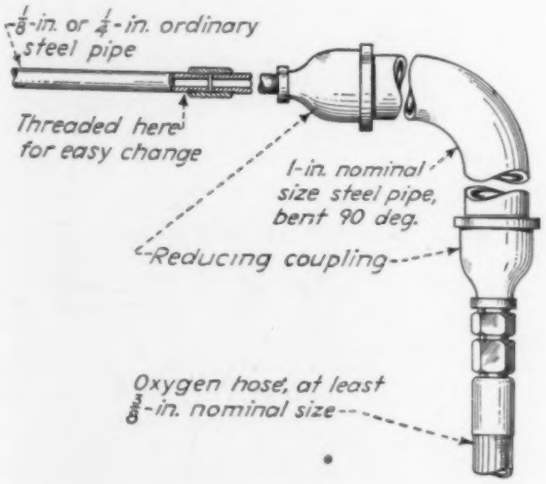
The lance pipe is connected to this 1-in. pipe by means of a reducing coupling. For moderately heavy work, $^{1}/_{4}$-in. steel pipe may be used for the lance, and even the heaviest work will not require more than $^{1}/_{4}$-in. pipe. The lance pipe should have threads that will work easily, as it is usually necessary to insert new lengths of pipe during cutting.

All pipe used must be completely free from oil and grease. Probably the most satisfactory method for removing oil and grease from new pipe is to heat it red hot, thus burning or charring all combustible material. Since the pipe is consumed in the lance operation, a sufficient number of lengths should be provided nearby, so that the cut can be completed without delay.

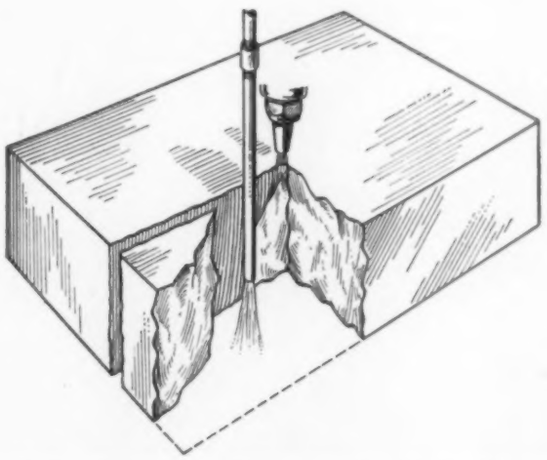
Starting the Lancing Operation

The oxygen lance differs from the cutting blowpipe in that there are no heating flames to maintain the material at the kindling point. It also differs from the cutting blowpipe in that once cutting has started the lance pipe itself burns and furnishes the heat necessary to keep the cut going.

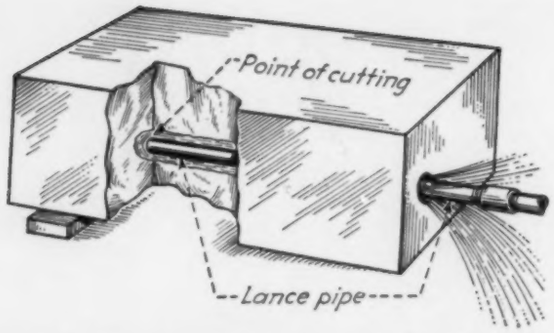
Heating a starting spot on the metal may be done in any one of a number of ways. If a cutting or welding blowpipe is handy, this furnishes the easiest means for heating the metal. Other methods are to place a red-hot rivet or a shovelful of red-hot coals on the spot, or to heat the end of the lance pipe in a fire until red hot. When a small stream of oxygen is allowed to pass through the pipe, the red-hot end burns brilliantly, giving sufficient heat to start the cut.


$^{1}/_{8}$-in. or $^{1}/_{4}$-in. ordinary steel pipe
Threaded here for easy change
1-in. nominal size steel pipe, bent 90 deg.
Reducing coupling
Oxygen hose, at least $^{3}/_{8}$-in. nominal size

The Oxygen Lance Is Essentially a $^{1}/_{8}$-In. or $^{1}/_{4}$-In. Ordinary Steel Pipe Attached to a Manifolded Supply of Oxygen. The 90° Bend in the Connecting Pipe Is Provided So That the Operator Can Stand to One Side



A Cutting Blowpipe Is Frequently Used in Conjunction with an Oxygen Lance to Raise the Metal to Be Cut to the Kindling Temperature. It Is Then Frequently Used Throughout the Operation to Speed Up the Cutting



This Sketch Illustrates the Cutting Action of the Oxygen Lance. The Lance Pipe Is Kept Pressed Against the End of the Hole. As Cutting Progresses the Lance Is Twisted First One Way and Then the Other

Oxygen Pressure Required

In using the oxygen lance it is desirable to have two workmen, one to operate the lance and the other to control the oxygen pressure at the manifold regulator. Only a few pounds' oxygen pressure is necessary to start lancing and this pressure is then increased as the lance penetrates the metal, the final pressure depending largely on the thickness of the material to be cut and also, to a certain extent, on the composition of the metal. Thus the maximum pressure is about 75 lb. psi. for medium carbon or machinery steel containing up to 0.50% carbon, and about 100 lb. psi. for low carbon or mild steel. If the job is very heavy, a third workman may be required to change oxygen cylinders and lance pipes.

Piercing Holes

Used alone, the oxygen lance is particularly effective in piercing holes. Its piercing action is very rapid, not more than two minutes' actual cutting time being required to sink a hole $2^1/_2$ in. in diam. one foot into a solid piece of iron or steel. This property of the oxygen lance makes it of the utmost value in the steel mill for routine and emergency tapping of blast and open-hearth furnaces, for opening frozen stoppers on steel ladles and for drilling holes in salamanders, spills and ladle skulls so that they can be blasted.

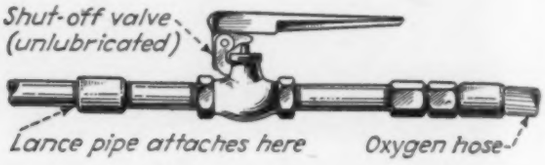
Modified Lance

For piercing small holes accurately, a modified form of oxygen lance is very useful. The oxygen hose leading from the cutting-oxygen regulator is attached to a suitable shut-off valve, arranged so that the sleeve coupling of a $^1/_8$-in. steel pipe will fit on the exit end of the nozzle. A half length of pipe is used to form the lance. The valve makes it possilbe for the operator to control the flow of oxygen exactly. This modified lance may be used advantageously to pierce small holes accurately through metal up to about 24 in. thick.

Cutting with Lance and Blowpipe

An oxygen lance and cutting blowpipe are frequently used together. The blowpipe furnishes the heat necessary to keep the cut going along the top surface and the lance carries the cut through to the bottom of the section.

As in all such operations, careful consideration should be given to the arrangement of the work before cutting is done. It is most important to provide for the free flow of cutting slag out of the bottom of the kerf. Wherever possible, heavy sections should be supported so as to give a clearance of at least 8 to 12 in. underneath.



A Shut-Off Valve May Be Supplied as a Part of the Lance So That the Operator Has Control of the Flow of Oxygen. Such a Valve Must Not Be Lubricated

In lance and blowpipe operations, two men at least will be working right at the cut. The work must be arranged so that there will not be interference by either with the other, and so that the whole operation can be carried out in accordance with safety rules.

Cutting Procedure

The cutting-blowpipe operator starts the cut at one side, using a blowpipe fitted with the largest size nozzle. The cut will soon penetrate from 4 to 8 in. into the steel mass, and as the blowpipe advances 2 or 3 in. along the line of cut, a steady stream of white hot slag will start dropping from the bottom of the cut. At this point an oxygen lance of $^1/_4$-in. pipe is brought into action. The oxygen pressure for the lance depends on the variety of steel—75 lb. psi. for medium carbon or machinery steel, and 100 lb. psi. for low carbon or mild steel. The oxygen lance reaction starts rapidly on the hot slag delivered by the cutting blowpipe and quickly carries the cut to the bottom of the section. The lance is then raised to the starting position and again lowered, removing another layer of metal as it descends. The action of the lance is thus somewhat like that of a crosscut saw.

It is sometimes possible to dispense with the blowpipe entirely after the lance has had a good start. However, this is possible only where due consideration has been given to the arrangement of the part to be cut with this possibility in mind.

Use of Two Lances

Heavy cuts can also be made by using two lances together. The second lance is often used to carry off the slag from the bottom of the cut and in this way speed the cutting considerably and actually lessen oxygen consumption.

Improved Equipment Aids Arc Welding of Sheet Metal Work

By R. A. Gast*

DEVELOPMENT of new welding equipment especially suited for light work has led to a tremendous increase in the use of the electric arc in sheet metal work.

One new welding machine produces highly controllable current as low as 10 amp. with no external attachments, such as auxiliary resistance. This makes it practical to weld sheet metal as thin as 24 gage.

The advantages of welding as applied to sheet metal work are numerous. The process is faster and cheaper than competitive methods. It is far superior in appearance and strength than crimping and soldering.

An ever-increasing number of shops are using it to advantage in fabrication and erection of pipes, duct work, stacks, skylights and virtually all types of structures.

A Jeannette, Pa., sheet metal contractor uses welding in the fabrication of a wide variety of industrial sheet metal products for local glass plants and other industrial concerns.

A typical product of this contractor is the automatic glass-molding machine air header shown in Fig. 1. These are built of 18-gage black iron. The welder is plying the carbon arc with his right hand and feeding in filler wire with his left. A portion of the bottom side of another header may be seen behind the workman. High quality welded work such as this has brought the contractor a lucrative business. The owner of this shop is not among the late arrivals in the use of the electric arc in sheet metal work.

A Toledo, Ohio, sheet metal contractor frequently receives jobs such as the dope kettles for a textile plant shown in Fig. 2. These are built from 14-gage black iron. The rim seen at the bottom of the kettle in this photograph is rolled from angle iron and welded intermittently to the kettle. Because of the relatively heavy gage of the metal used, the welder shown in the picture is using a welding rod instead of a carbon arc.

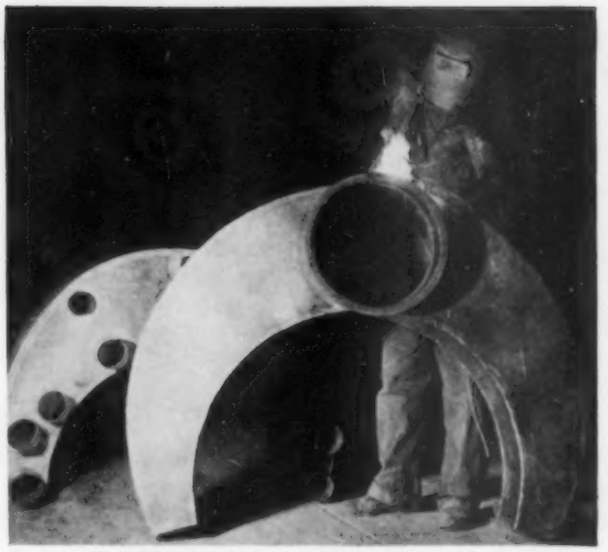


Fig. 1—This Welder Is Constructing an Air Header for an Automatic Glass-Molding Machine

Sheet metal jobs such as this are difficult to do without arc-welding equipment.

On finer work, such as the welding of galvanized hinges and handles, the concern employs the carbon arc and filler wire, as shown in Fig. 3. No appreciable damage to the galvanized surface is noted. A fellow worker is holding the handle in place with a wooden rod.

A weld of this type is fully as strong as the adjacent metal.

Occasionally a sheet metal contractor will receive a job which seems impossible to construct with the ordinary method of crimping. Moreover, soldering does not offer sufficient strength for the purpose.

An example of such a project is a storage bin for nuts and bolts. This bin is designed for installation around a round building column to conserve floor space. It was constructed of 18-gage black iron by means of arc welding. The New York contractor who did the job would have found it virtually impossible to do without arc-welding equipment.

* Mechanical Engineer, The Lincoln Electric Co., Cleveland, Ohio.

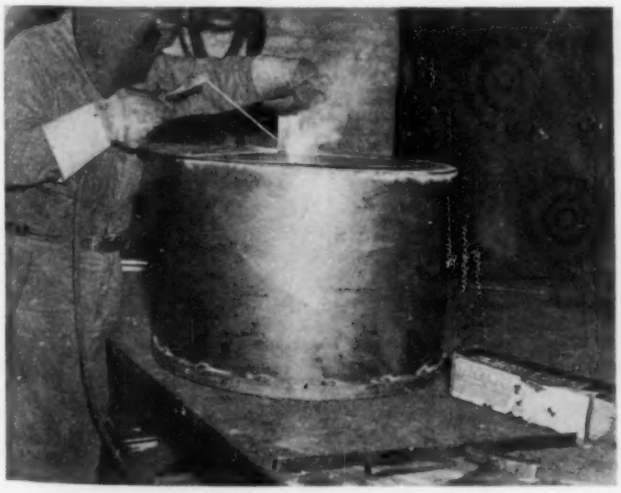


Fig. 2—These Dope Kettles Are Fabricated by Means of the Electric Arc of 14-Gage Black Iron and Angle Iron

Fig. 3—Welding a Galvanized Handle on One of the Dope Kettles

The galvanized coating is not seriously disturbed by the arc heat.

Converting Ore Boats

By Robert Wagner*

MANY ore boats from the Great Lakes are now being converted into ocean tankers to meet heavy war demands. Here is an effective welding procedure used by Dolomite Marine Corporation of Rochester, N. Y., under supervision of Walter G. Dick, welding foreman.

On most ships, it was found that all sea valves in the engine room had to be removed and the resulting 8-in. to 10-in. holes in the hull plates closed. Most of the holes resulted near the bottom of the curved engine room hull plates so it was possible to perform most of the welding in a semi-flat position.

First, the hull plate was flame cut, as shown in Fig. 1, to remove the attachment holes from the plate. The edges of the openings were then beveled from the inside to a 30° angle leaving a $^1/_8$-in. shoulder on the outside edge of the plate. (See sketch section *A-A*.) Next, a piece of similar plate was cut $^1/_4$ in. smaller than the hull holes. The edges of these plates were prepared in the same manner performed on the hull plates—30° bevel and $^1/_8$-in. shoulder. This plate was then fitted into the hull opening, as shown in Fig. 2, and tack welded into place leaving a $^1/_8$-in. gap between hull plate and patch plate. Patch plate, of course, was shaped to conform with the curve of the hull before being tacked into place.

Welding procedure was to start bead at the highest point on the "V" joint and weld down—other half of patch plate being joined in the same manner. Welding was started with $^1/_8$-in. all-purpose rod and finished with $^5/_{32}$-in. rod of the same type. Each pass of the multiple bead was run from top to bottom—opposite the last one completed.

None of the beads in the multiple pass were weaved more than $^5/_{16}$ in. Each pass was cleaned thoroughly before another was deposited. Finish bead was not built up higher than $^1/_8$ in. above the shell plate. Welding was finished completely on the inside of the patch before outside was begun. Outside joint was chipped free of slag and small weld distortions before outside bead was run. The same welding procedure as used on the inside joint was performed—on outside with only two passes with $^1/_8$-in. all-purpose rod being required to finish the weld. After grinding and painting, the repair was invisible from the outside hull. This same method of repair has been used successfully on various types of ships with notable success.

Take the following precautions when using this method of repair:

1. Use a 60° included angle for the bevel. If the angle is too narrow, incomplete penetration in the root of the "V" will result. If the "V" is too wide, an excess amount of weld metal will be necessary—causing undue stresses in the joint and plate.

2. The setup must be made carefully so that the gap between the edges will be uniform.

3. Operator must be careful that each pass of weld metal is sound and fused completely into the preceding pass and the sides of the "V."

4. Welding, once started, must be completed without interruption both inside and out. If only partially completed and allowed to cool, crack of weld metal will result.

* Hobart Brothers Co., Troy, Ohio.

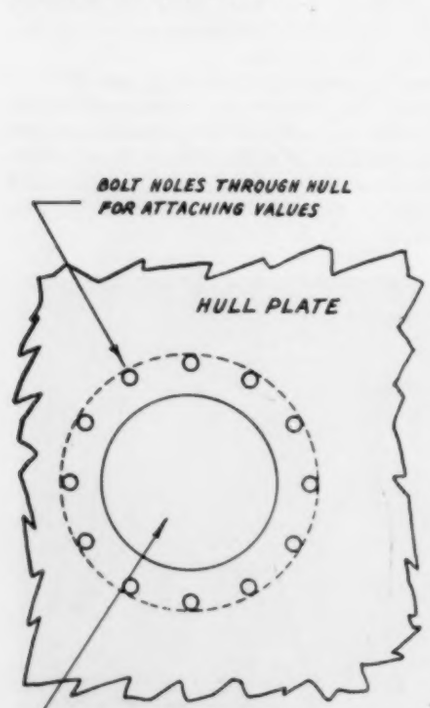


FIG. 1
BROKEN LINE SHOWS LOCATION OF CUT

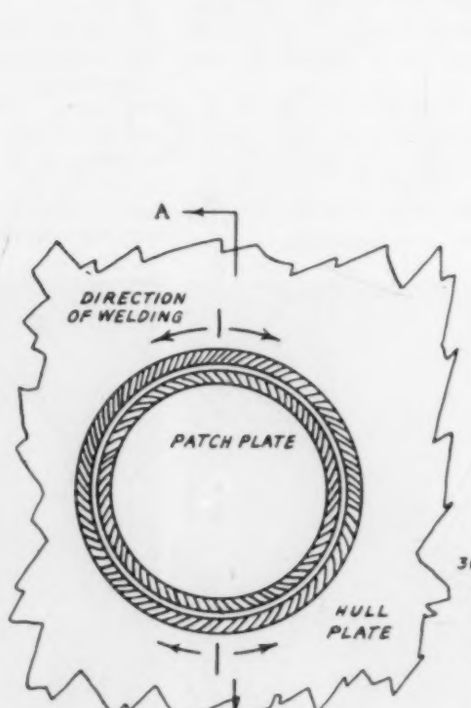
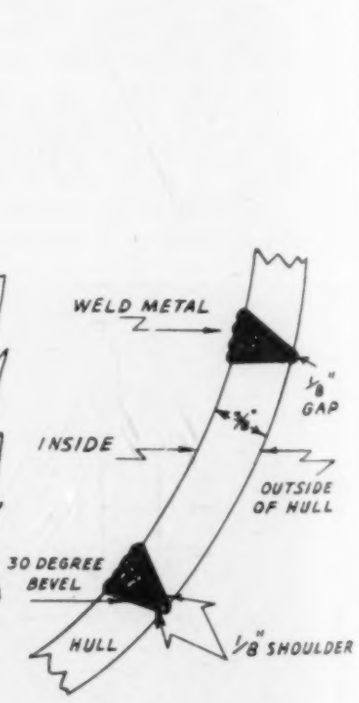


FIG. 2



SECTION A-A

Drawings courtesy Hobart Brothers Co.

THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

PRESIDENT'S MESSAGE

The establishment of priorities has the following objectives in view: control of the use of raw materials by preventing their diversion to non-war activities, the rationing of materials of which there is a shortage even for war production and the prevention of wastage.

There is need for controlling the production and distribution of electrodes and priorities have been extended to include them. Electrodes are used for three principal purposes: fabrication, maintenance and training or instruction.

The consumption of electrodes in fabrication is controlled rather definitely by the priority established on the base metal. If no steel is available for a fabricated structure, no electrodes will be ordered or consumed. Electrodes differ from other raw materials in that they are not primary materials of construction. They differ also in that there is no exact knowledge available as to the quantity required in fabrication of any given structure. The quantity of electrodes to be used falls within rather wide limits and is not subject to control.

The consumption of alloys in electrodes is also to a great extent fixed by the priorities on base materials. If alloy steels are used in the base material then, except for thin sections, alloys must be allowed in the electrode. In good engineering practice there will be little tendency to build up the alloy content of the weld metal as it is undesirable to have a greater yield strength in the weld metal than in the base metal.

There are exceptions as alloy electrodes may be used for hard facing and high alloy (austenitic) electrodes may be used for welding low alloy steels. The use of alloys for hard facing is normally economical because it permits the use of cheaper base materials. For some applications the use of high alloy electrodes is essential and economical. Their use in welding low alloy steels, however, may not be warranted except under very special conditions. It may be questioned whether high alloy electrodes should be permitted merely to avoid preheating or postheating of the welded structures.

The establishment of a priority system on electrodes for maintenance warrants careful study. A few years ago 20 to 25% of the total consumption of electrodes was for maintenance. At present, probably 5 to 10% of electrodes are so used.

The control of maintenance consumption in plants obtaining electrodes for fabrication is impracticable as there will probably be no segregation of electrodes for production and for maintenance.

If an industrial plant, transportation system or agricultural unit is permitted to operate, it is important that their facilities be maintained in serviceable condition at the least cost in labor and materials. If maintenance is delayed too long extra costs will be involved because of the greater rate of wear for badly worn parts. If broken parts can be repaired or worn parts built up by welding, savings in labor and material generally result over the replacement of parts. It is reasonable to encourage welding by establishing a higher priority for electrodes than for replacement parts.

Some maintenance as, for example, repairs on farm equipment broken during the season of its use must be attended to without delay if economic loss is to be avoided. As the tonnage of electrodes used for general maintenance purposes is relatively small, and there is a probability of considerable loss if maintenance is neglected, a liberal policy in assigning electrodes for maintenance work is justified.

The tonnage of electrodes used for training purposes is considerable. If trainees are not given courses fitting them for industrial welding, the electrodes consumed are largely wasted. Control of electrode use may be secured through regulation of the course of instruction. The AMERICAN WELDING SOCIETY'S Minimum Requirements for Training of Welding Operators should be of great value in fixing standards of instruction. Regulation of distribution of electrodes may well exclude sale of electrodes to all schools, whether government or private, which do not fit their students to undertake industrial welding. Except for engineering schools, the available supply does not warrant use of electrodes in training which does not involve industrial employment.

The control of wastage of electrodes is a more serious problem. Wastage may occur because of long stub ends or the throwing away of whole electrodes due to damage to coating or for other reasons. Under piece work there is little incentive for workmen to conserve electrodes. Posters or other methods of reaching the welding operator will be found futile. Whether electrodes are efficiently used will depend upon the shop practice established by the supervisory staff of the industrial plant. The problem is to reach the administrators and engineers of the plant. The establishment of priorities will not solve the wastage problem. On the other hand, it will encourage wastage in those plants operating under the highest priorities. The problem is the more difficult because of the shortage of experienced welding engineers.

PUBLICATION OF CHARTS

From time to time, the AMERICAN WELDING SOCIETY receives important papers, including charts drawn on fine cross-section paper. It is extremely difficult to reproduce these charts. THE WELDING JOURNAL appropriation is not sufficient to have the charts redrawn. Authors are urged to use tracing cloth or plain black and white papers with only the largest squares inked in lightly. Moreover, the custom of typing headings or other information on the cross-section paper renders reading of this material almost impossible. If typing headings or information is necessary, it is suggested that the material be typed on a white slip and pasted on the cross-section paper.

AMERICAN SOCIETY FOR TESTING MATERIALS ANNUAL MEETING

More than 100 technical papers and reports are scheduled for presentation at the Forty-fifth Annual Meeting of the American Society for Testing Materials to be held at Chalfonte-Haddon Hall, Atlantic City, from Monday, June 22nd through Friday, June 26th. During this week there will be also more than 150 meetings of technical committees. Some 18 separate official technical sessions will be scheduled at which the technical reports and papers will be presented and discussed.

Since 1942 is a so-called "Book of Standards year" for the Society, the committee reports will be of more than usual significance since each group will attempt to have its specifications as up to date as possible for inclusion in the triennially published Book, scheduled for appearance late in November.

Two outstanding technical features are the Symposium on Radiography for which three sessions are scheduled and a Discussion on Solvent Action of Water Vapor at High Temperature and Pressure which is in the nature of an extensive round-table discussion.

Subjects which will be covered in technical papers in the field of ferrous and nonferrous metals include the following: Fatigue tests as a means of evaluating corrosion damage, influence of combination of principal stresses on fatigue of metals, creep strength of malleable iron, correlation of mechanical properties with radiographic appearance of magnesium alloys, creep characteristics of some copper alloys

at elevated temperatures, comparative quality of converter cast steels and a new magnetic test method.

Further announcements are to be made concerning special speakers, the Edgar Marburg Lecturer and other features of the meeting.

COMMUNICATION TO THE EDITOR

May 15, 1942

Mr. W. Spraragen, Editor
The Welding Journal
New York City, New York

Dear Mr. Spraragen:

Our greatest progress in the furtherance of our present war effort is not going to be by building more plant but by using more efficiently the plant we have. The greatest error we have made so far is that we think of production in terms of man-hours rather than in terms of what that man in that hour can do.

When we begin to increase the efficiency of our present operations, it will be a very simple thing to double our present production with the same number of man-hours. We can, inside of another few months, double that again if the efficient methods which the industrial geniuses know can be applied and are enthusiastically followed.

As an example of this, in the present building of ships, 1/8-in. and 5/32-in. electrodes are largely being used for welding. If these should be changed to 3/16 in. and 1/4 in., the speed of welding would be more than doubled. The cost of the electrode also would be more than doubled. The cost of the deposited metal would be reduced, since the production of welded joints by the same number of man-hours would be increased and the reliability of the joint would be increased.

The great problem we have is not more welders, more shipyards and more men but more efficiency with what we now have. Man-hours alone will never beat the Axis, as we are seeing. The efficiency possible by the application of industrial genius will.

Yours very truly,
J. F. LINCOLN, *President*,
The Lincoln Electric Company,
Cleveland, Ohio

THE INSIDE OF ARC WELDING

A new training film in full color and sound in 6 parts. Each part is complete in itself—a 10-minute, full-color, sound production covering one particular phase of arc welding in full detail.

1. *Fundamentals*—the basic principles of shielded-metal arc welding, the four factors that determine the quality of the finished weld: length of arc, angle of electrode, current setting and speed of travel.
2. *Flat Position*—detailed demonstrations of how to minimize arc-blow and make good welds in the flat position—full-color photographs showing what happens inside the molten pool.
3. *Horizontal Position*—proper procedure for making good welds in the horizontal position—how to manipulate the electrode to provide properly shaped beads and good fusion.
4. *Alternating Current*—Flat and Horizontal—how to take advantage of the absence of arc-blow with a-c—the use of larger electrodes and higher current with resulting higher deposition rate.
5. *Vertical Position*—do's and don'ts for welding in the vertical position—how to control the molten metal and overcome arc-blow as well as other factors to be considered when welding in this position.
6. *Overhead Position*—a clear, concise explanation of the principles that govern arc welding in the overhead position—with particular attention given to control of the four fundamental factors.

Available through the General Electric Company.

ALL OUT FOR VICTORY

Mrs. Bertha Downing is the first woman to successfully pass the American Shipping Board Welding Test in all positions,

and, in line with the Government policy to replace men with women, wherever possible, is now helping to train other women for shipyard welding.

The first class of women trained will go to work as soon as their training is completed.

Mrs. Downing received her training at the Signal Hill School of Welding, Long Beach, Cal.

I wish I could tell you all the swell things the USO is doing! But it would take pages. I can tell you, though, that it means a whale of a lot to the fellows in the army camps and naval stations.

But it takes money to do these things—a lot of money! Money that the USO can get only from us—from you and me and millions of others.

We in Hollywood feel proud that we've been able to help this great work along—by participating in USO camp shows, by giving money, by doing whatever we can.

So I know that you'll feel that same pride when you make your own contribution. You never gave to a better cause.

Edward G. Robinson

Send your contribution to your local USO chairman or to National Headquarters, USO, Empire State Building, New York City.

ELECTROLOY ALLOYS for RESISTANCE WELDING ELECTRODES and DIES

Spot
Seam
Butt
Flash
Projection

ELECTROLOY ALLOYS were developed specifically for the resistance welding industry. ELECTROLOY ALLOYS cover the full range of physical properties necessary to the manufacturers and users of resistance welding equipment.

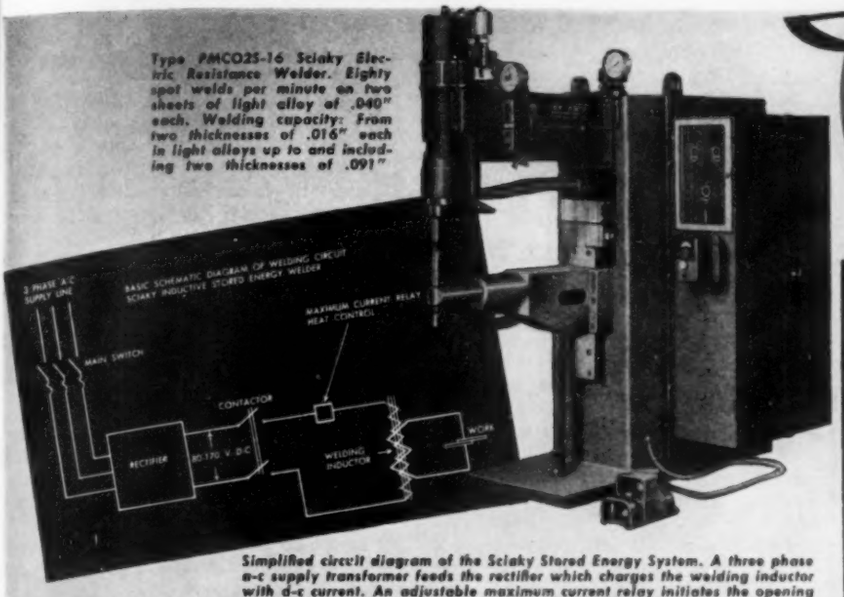
Our engineers will be glad to make recommendations for your special electrodes. Submit samples or specifications.

Catalog and prices available on request.

THE ELECTROLOY COMPANY, Inc. 1600 Seaview Avenue, BRIDGEPORT, Connecticut

AMAZING POWER COST SAVINGS

WITH THE SCIAKY* PROCESS FOR SPOT WELDING ALUMINUM



Type PMCO25-16 Sciaky Electric Resistance Welder. Eighty spot welds per minute on two sheets of light alloy of .040" each. Welding capacity: From two thicknesses of .016" each in light alloys up to and including two thicknesses of .091"

Simplified circuit diagram of the Sciaky Stored Energy System. A three phase a-c supply transformer feeds the rectifier which charges the welding inductor with d-c current. An adjustable maximum current relay initiates the opening of the d-c charging circuit after a predetermined amount of electromagnetic energy has been stored in the inductor.

Electric resistance welding of aluminum and its alloys requires currents of extremely high intensity. (For example, a secondary current of approximately 150,000 amperes is required for spot welding two pieces of 3/16" aluminum alloys.) When a spot weld is made by a conventional A-C SINGLE PHASE Welder, the sudden demand on the supply line unbalances the line and causes a severe voltage drop.

Not only is the resulting "flicker" an annoying nuisance, but the *maximum demand* is boosted to a point where power costs become prohibitive. A battery of such welders requires special, expensive, heavy-duty power lines to handle the peak loads, *if indeed the power is available.*

Utilizing the stored energy principle, the Sciaky Welder has a peak demand of approximately 1/10th that of an a-c machine of comparable capacity. The Sciaky method uses three phase 220 to 550 a-c which is rectified and reduced to 80 to 170 volts d-c. This direct current is stored in the form of electromagnetic energy in a welding inductor during a "charging" period, and then released practically instantaneously as low-voltage, high-amperage welding current. Moreover, a balanced condition is maintained on all three phases of the supply line at near unity power factor.

The stored energy principle, the patented variable pressure cycle and an exclusive preheating feature have made the Sciaky Process for aluminum welding preferred by practically every major producer of aircraft in America.

SCIAKY BROS.

Manufacturers of a Complete Line of D-C and A-C Electric Resistance Welding Machines

11001 Cottage Grove Avenue, Chicago, Illinois

*Pronounced See-ack-ee

Stored Energy DOES IT!

WHY STORED ENERGY REDUCES POWER COSTS

SCIAKY D-C WELDING REQUIRES *LOW* "MAXIMUM DEMAND"

The analogy of a water pipe and pail illustrates the stored energy principle. The pail is filled from a comparatively small pipe and its entire contents dumped in a fraction of the filling time. This parallels the comparatively slow (actually, a fraction of a second) storage of electromagnetic energy, and its instantaneous release as welding current.

CONVENTIONAL A-C WELDING REQUIRES *HIGH* "MAXIMUM DEMAND"

To continue the analogy, the demands on the power lines by an a-c welder, by comparison, would require a pipe large enough to supply instantly, a volume of water equivalent to the entire contents of the pail. It is this excessive "maximum demand" that runs up the cost for current.

SCIAKY — **PROCESS ELECTRIC RESISTANCE WELDING**
STORED ENERGY • VARIABLE PRESSURE

NEW SHIPYARD ON LAKES SETS GOAL TO PRODUCE ONE SUB-CHASER A WEEK

Construction of the first all-steel anti-submarine patrol ships ever built in the Chicago region will begin in early summer at the shipyard now being erected by the Pullman-Standard Car Manufacturing Company.

By means of streamlined production methods which call for fabrication of large sections of the ships in the company's car works with final assembly on the ways, the yard will ultimately turn out a ship a week, according to Commander W. R. Dowd, supervisor of shipbuilding, U. S. N., for the vicinity of Chicago, and C. A. Liddle, Pullman-Standard President, who made the announcement jointly.

Present contract with the Navy calls for construction of 50 of the sleek, Diesel-powered fighting ships. The Navy advanced $4,300,000 for the new plant.

It was pointed out that many of the trades employed in car building are identical to those required in shipbuilding. Car workers who can be adapted readily to shipbuilding include welders, riveters, electricians, pipe and frame fitters, sheet metal workers, joiners, painters, plumbers and cabinet makers.

Although almost all present employees of the car works will work on the ships, several thousand men will have to be engaged from the outside and thoroughly trained in these and other shipbuilding crafts, it was said.

Facilities are already being set up with cooperation of public vocational training authorities for training these men and also workers who are needed by two other Chicago concerns with prime navy shipbuilding contracts, Chicago Bridge & Iron Co. and Henry C. Grebe & Co. Vocational schools will be utilized for this war-training effort.

In addition to ships, Pullman-Standard is turning out airplane parts, tanks, artillery shells, mortars and gun carriages.

WELDING IN SHIP CONSTRUCTION

"A victorious symbol of arc-welding achievement," according to W. H. Hobart, Vice-President of Hobart Brothers Co., Troy, Ohio, manufacturers of arc-welding equipment, "was the recent simultaneous launching of three 10,000-ton cargo ships at the Todd Shipbuilding Corp. at South Portland, Maine. This was the first launching in maritime history when three ships as large as 10,000 tons were launched at the same time." (See cover picture.)

"The reasons we can accredit our growing bridge of ships in large part to arc welding," says Mr. Hobart, "are threefold. The most obvious advantage of arc welded ships is the tremendous savings in steel due to the absence of overlapping plates, thus increasing the speed and cargo-carrying capacity of each ship. Secondly, welding operators can be trained far more rapidly than riveters. Today's modern arc-welding schools can turn out trained arc welders in from four to six weeks' time.

"Thirdly, welding has permitted production line assembly of large ship sections in factory shops before being fitted to the frame of the ship. Daily improvements are being made to increase ship production by arc welding. For instance, experiments in launching small Navy boats upside down has proved so successful that engineers are going to try this method on larger ships. Ships launched in this manner will increase the productivity of each welding operator and lessen fatigue since a majority of the welds can be made in the convenient downhand position. Without question, we can consider arc welding the most important 'victory' tool in maritime history."

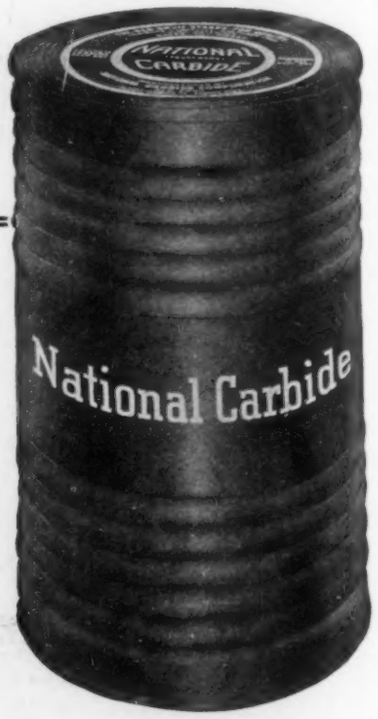
"FLEET-FILLET" WELDING TECHNIQUE BULLETIN

The "Fleet-Fillet" technique of arc welding, which permits up to 100% faster fillet welding and which will thus greatly speed up production of welded ships, tanks, guns and other war-vital products, is described and illustrated in a new bulletin just published by The Lincoln Electric Company, Cleveland, Ohio.

Published in the interests of the war effort for the guidance of war production plants seeking maximum output of ships,

National
Carbide
IN THE RED DRUM

EFFICIENT
ECONOMICAL
DEPENDABLE



FOR WELDING and CUTTING
Use National Carbide in the Red Drum
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.

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To manufacturers of

Stainless Steel Electrodes

Foote

Pariflux-Calgran

(Calcium Fluoride) (Calcium Carbonate)

1. Graded in particle size to materially reduce drying cracks.
2. Produced from a selected marble to insure low reactivity with sodium silicate.

FACTORIES—Wyndmoor, Pa.—Philadelphia, Pa.—Exton, Pa.

FOOTE MINERAL CO.

Sales Office—1600 Summer Street, Philadelphia, Pa.

tanks, guns and other military and naval equipment utilizing welded construction, the new bulletin is entitled, *The "Fleet-Fillet" Welding Technique for Speeding War Production*. It contains 18 pages, 8½ x 11 in., and 36 illustrations, including photos and line drawings. Planned as ready reference material for plant production officials, welding operators and all others concerned with welding, the bulletin is concisely written and printed throughout in black ink on good quality white coated paper.

WELDING AND METAL CUTTING

Welding and Metal Cutting—Editor, E. Molloy. The present book is intended to give the mechanical engineer a practical survey of the three main types of welding which he is likely to encounter, namely the oxyacetylene process, electric arc welding and electric resistance welding. These three important branches of the subject are dealt with in the early chapters. The specialized, but highly interesting, process of thermit welding has been treated separately in Chapter VI. The process of metal cutting using the oxyacetylene torch is described in detail in Chapter VII. Chapter VIII explains how the same principles have been applied in the latest types of oxygen cutting machines. Every engineer who is interested in production work, general engineering, repair work or engineering construction, will find this practical survey of present-day methods and equipment an invaluable aid. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y. Price, $2.50.

GENERAL MOTORS PROMOTIONS

H. L. Hamilton, Vice-President of the General Motors Corporation, announced today a number of promotions within the Electro-Motive Division of La Grange designed to expedite the production and delivery of essential war products.

E. Kuehn, formerly Factory Manager, assumes contact responsibilities in the railroad transportation field as Special Representative working directly with Mr. Hamilton.

A. J. Heseltine has been promoted from the position of Chief Inspector to Factory Manager with J. H. Hruska advancing to the Chief Inspector post.

L. E. Simon receives the appointment of Chief Metallurgist, replacing Mr. Hruska.

Mr. Heseltine, one of the oldest employees from the standpoint of continuous service with Electro-Motive (16 years), formerly was with the General Electric Corporation. Starting as Superintendent of Installations of Electro-Motive engines at the St. Louis Car Company, he was advanced from Shop Superintendent to Assistant Factory Manager and to Chief Inspector, the position he now is relinquishing to become the new Factory Manager.

Mr. Hruska, a graduate of Prague University, received his early training at the Skoda Arms Works in Czechoslovakia. Coming to this country in 1923, he went to work for the International Harvester Company and later for the Carnegie Steel Works. In 1935 he came to the Electro-Motive Division in the position of Chief Metallurgist.

Mr. L. E. Simon came to Electro-Motive recently after a number of years' experience with the General Motors Research Division in Detroit.

Messrs. Kuehn, Heseltine and Hruska are members of the AMERICAN WELDING SOCIETY.

ELECTRICAL TESTING LABS., INC.

Electrical Testing Laboratories, Inc., having acquired the plant and equipment, and having taken over the staff of Electrical Testing Laboratories, 2 East End Ave., at 79th St., New York, N. Y., offers its services to government and industry.

Officers of Electrical Testing Laboratories, Inc., are as follows: Preston S. Millar, President; F. Malcolm Farmer, Vice-President and Chief Engineer; Denis J. Lees, Vice-President and Treasurer; Gordon Thompson, Assistant Treasurer; Caroline E. Slocum, Secretary.

The facilities of ETL, Inc., are exceptionally comprehensive in the electrical field. Extensive facilities also are available for optical, physical, mechanical and chemical laboratory operations. The machine shop of ETL, Inc., is engaged in constructing and maintaining numerous gages and instruments that are the implements of skilled technical work. Something of the scope of facilities and the range of operations is illustrated by such diverse subjects of investigation as vitamin content of fish oils; hydraulic bursting strength of large cast-iron pipe fittings; durability of playing cards; effectiveness of insect destroyers; color fastness or weather resistance of paints, paper and fabrics; and increasingly a wide variety of activities directed toward assistance in prosecution of the war.

Some of the services are inspection of purchases; supplementing industry laboratories; surveys, certification; development and research; and private laboratories.

UNUSUAL WELDED FLOOR LAMP

The accompanying photo showing an unusual floor lamp built by welding was sent to The Lincoln Electric Co., Cleveland, Ohio, by Ollie Moore and Lee Burklow, welding instructors at Hume Fogg Technical & Vocational High School, Nashville, Tenn.

The framework of the lamp is made of ¾-in. water pipe. The berries are steel balls salvaged from truck bearings and the scrolls are pieces of scrap metal. The leaves were made by cutting up empty electrode containers with tin snips and grooving by hand.

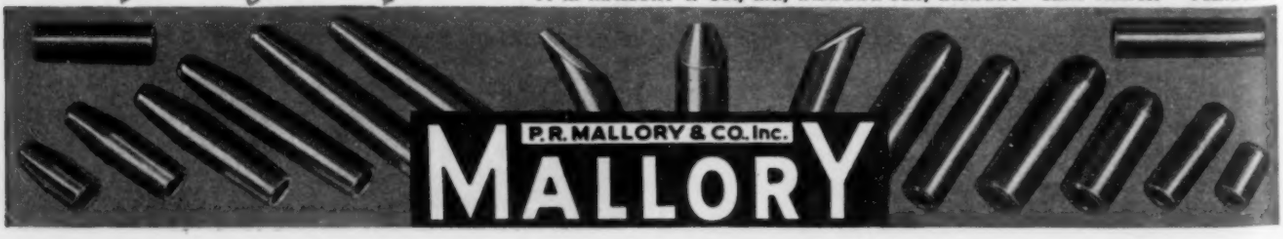
Welders Moore and Burklow are shown in the photograph at right and left, respectively.

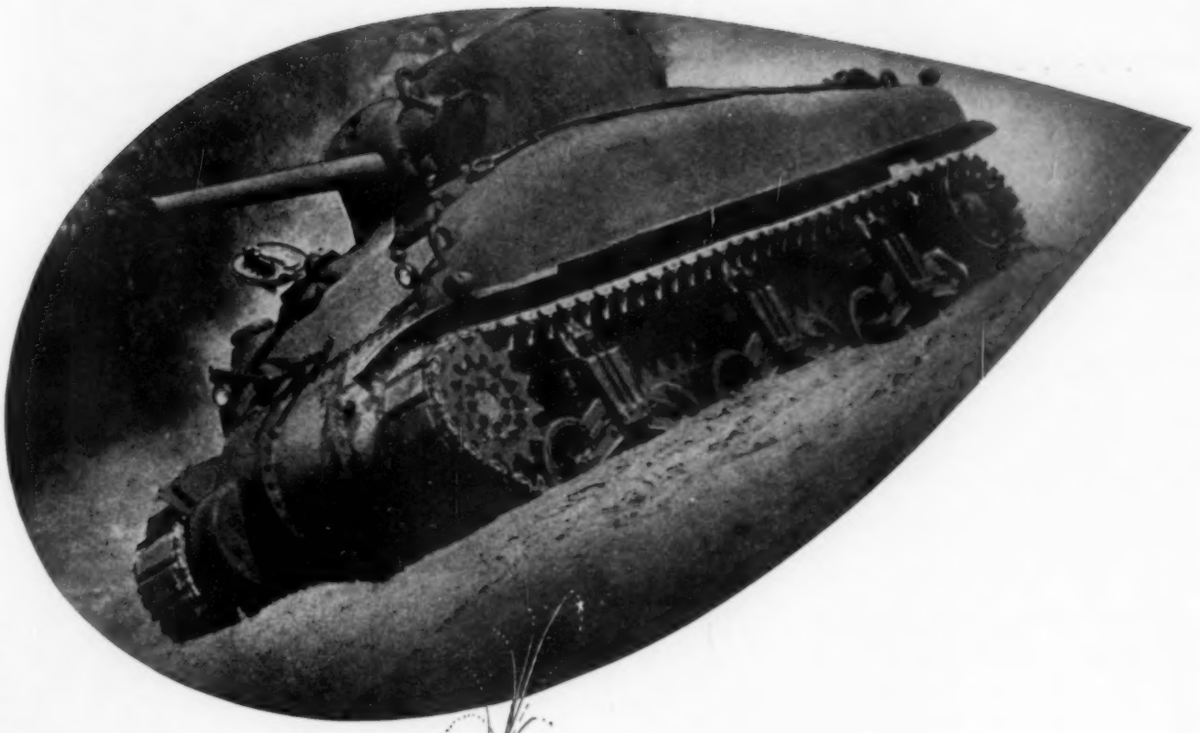
MALLORY STANDARDIZED WELDING ELECTRODES

SPEEDIER PRODUCTION
LESS DOWN TIME
BETTER WELDING
LOWER COST

The men who man high speed spot welding guns, single and multiple spot welders, seam welders and flash welders . . . rely on Mallory for long life electrodes! Write for your free copy of the factual Mallory Resistance Welding Data Book . . . today.

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA • *Cable Address* — PELMALLO





PAGE ELECTRODES

FOR ARMOR WELDING

ACCEPTED FOR WELDING AMERICA'S NEW VICTORY TANKS

It was inevitable that tank production should turn to welding as the shortest road to provide the fleets of tanks required for America's Armed Forces.

And in this development it was just as inevitable that **PAGE** would be found ready and able to take its full share.

So, now, it can be announced that an electrode developed exclusively by **PAGE** for welding armor plate has successfully met all ballistic tests on plates submitted to the Army Ordnance Department by the manufacturers of tanks.

PAGE WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION • MONESSEN, PA., ATLANTA, CHICAGO, NEW YORK, PITTSBURGH, SAN FRANCISCO

AMERICAN CHAIN & CABLE COMPANY, Inc.
BRIDGEPORT • CONNECTICUT

ERECTING AND INSTALLATION WORK

Erecting and Installation Work—Editor, E. Molloy. The information contained in this book has been collated to provide erectors and installation engineers with a sound reliable guide on the procedure to be adopted in dealing with the various types of engines and power-driven machinery. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y. Price, $2.50.

LINCOLN DETROIT DISTRICT MANAGER

A. F. Boucher, District Manager of the Detroit Office of The Lincoln Electric Co., Cleveland, Ohio, has been called to active duty in his capacity as a reserve officer. He will be attached with the Ordnance Department, and for the time being will be stationed with the Detroit Ordnance District.

Boucher's duties as District Manager of the Detroit Office will be assumed by C. H. Buckmaster of the company's Pittsburgh Office, and J. H. Cunningham of the Detroit Office will take over Buckmaster's duties at the Pittsburgh Office.

The company simultaneously announces that George Bain is being transferred from the Detroit area to the Saginaw area.

These changes became effective March 6th, according to announcement just received from the company.

VICTORY IDEAS

In order to get valuable information about arc welding to factory executives in a hurry, Hobart Brothers Co. has added a "Welding Ideas For Victory" division to their regular $200 monthly Arc-Welding News Contest. Acting as a clearing house for defense welding ideas, this division will prepare and release to the general public all welding ideas judged worth while to our offense production.

There has been no limitations placed on the number of prizes to be offered every month for "Welding Ideas For Victory." The company promises, however, to purchase and publicize immediately every worth while welding idea.

Send your ideas for victory to "Offense Ideas," Hobart Brothers Co., Troy, Ohio. Reports on the value of items sent in will be mailed back promptly.

MACHINE MAINTENANCE WITH METALLIZING

A 16-page Bulletin 42A, just published by Metallizing Engineering Co., Inc., Long Island City, N. Y., describes the metallizing process and equipment for its application. Tells briefly how essential industries are eliminating replacements, and increasing service-life of equipment now difficult to replace, by building up worn diameters with any desired wear, and corrosion-resistant sprayed metal. Also indicates how metallizing is used to rapidly salvage mismachined parts and defective castings in production. Examples given to show how metallized "inserts" and coatings are helping manufacturers conserve vital metals.

OBITUARY

Fred J. Maeurer

With deep regret we announce the death of one of our members, Fred J. Maeurer, who died suddenly on April 13th. Fred became associated with the oxyacetylene industry on November 1, 1909, when he joined the forces of the Davis-Bournonville Company, Jersey City; his record of service with Air Reduction Sales Co. dates from March 17, 1922, the date of the acquisition of the DB Company by Airco. Fred's service record of nearly thirty-three years in the industry covered a wide variety of activities. In the early days he was superintendent of the DB Welding Shop at Jersey City, and for a number of years was located in Chicago in the capacity of a service engineer. For the past thirteen years he had been associated with the Applied Engineering Department, Air Reduction Co., as a specialist. He had a broad knowledge of the practical applications of oxyacetylene welding and cutting, and had made many friends throughout industry.

For SAFETY SPEED ECONOMY

REGO

MANIFOLDS
REGULATORS
VALVES and
FITTINGS

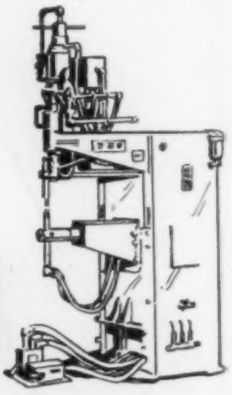
to control high pressure gases

The BASTIAN-BLESSING Co.

4241 PETERSON AVE. CHICAGO

Pioneers and Manufacturers of Precision Equipment for Using and Controlling High Pressure Gases

WELDING HITS A NEW HIGH



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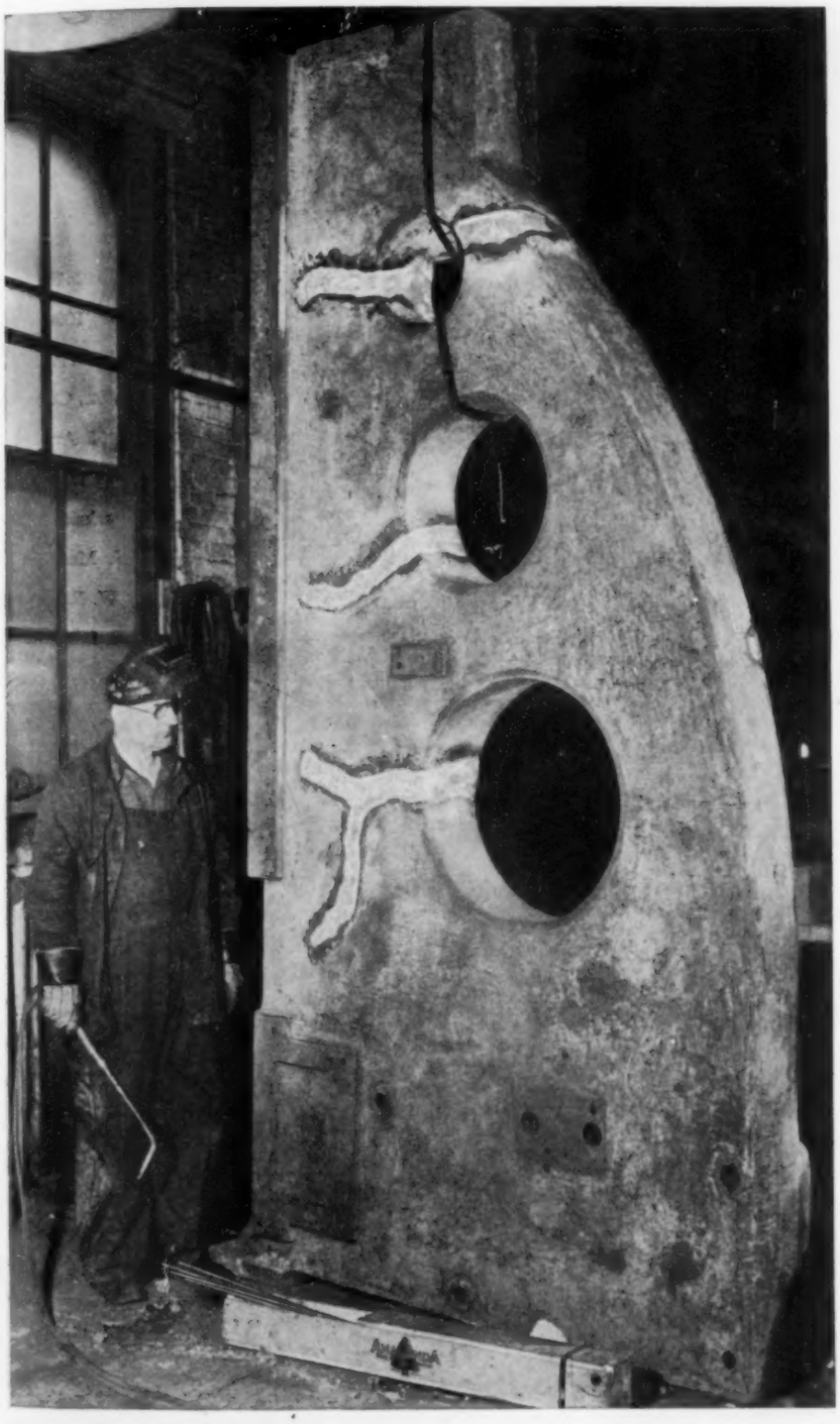

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The Hebeler Welding Company of Buffalo, repair welding specialists, provided the way to give our war program the use of this mill with a minimum delay . . . repair welding with Anaconda 997 Low Fuming Rod.

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Oxyacetylene cutting, a fast and accurate means of shaping steel, is discussed in the light of its ability to speed up and simplify production procedure. Reference is also made to production welding, the welding of jigs and fixtures, flame hardening, low temperature brazing, flame cleaning and various other metal working techniques.

Copies of "Airco in Aviation" can be obtained by writing to the Advertising Dept., Air Reduction, 60 East 42nd St., New York, N. Y.

Employment Service Bulletin

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A-436. Welding Engineer desires position. 36 years of age, arrived in the United States about the first of the year. Has received first citizenship papers. Graduate electrical engineer University of Grenoble, France, and received degree of Welding Engineer from the Institute of Autogen Welding in Paris. Has had seven years' experience in welding construction. Can serve as inspector of welding or as Executive Engineer in welding construction or installation or in welding laboratory.

A-437. Welder, 2½ years in trade. Thorough experienced in 16- to 22-gage sheet metal work, oxyacetylene, also familiar with silver soldering, bronze welding and light gage arc welding. Metropolitan area New York. Married. Age 32.

A-438. Welder. 4½ years' actual welding experience; past two years as a sales and service man for welding electrode manufacturer. Prefer position as supervisor of welding in or near New York.

A-439. Arc welding on sheet metal and stainless steel position desired; defense work only; metropolitan New York area. Four years of welding experience. Last year with large electric welding manufacturing company. College degree. Blueprint reading, construction experience. Married. Age 31.

POSITIONS VACANT

V-116. Experienced welder with knowledge of pre-stressing and welding of stainless alloys including heavy 4-6 chrome steel sections.

V-117. Welding Engineer thoroughly experienced in all classes of welding. Applicant should be capable supervisor and familiar with requirements of American Bureau of Shipping, Bureau of Marine Inspection and Navigation, U. S. Maritime Commission, U. S. Engineer Corps and A.S.M.E. Code, particularly with regard to welding steel plates.

V-118. See page 414.

List of New Members

April 1 to April 30, 1942

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Gilley, Herman J. (D), 2649 Pike Rd., Birmingham, Ala.
Webb, James K. (D), 3153 Norwood Blvd., Birmingham, Ala.

BOSTON

Bain, Earle S. (D), 167 Union St., S. Weymouth, Mass.
Coveney, James (C), The Palmer Elec. & Mfg. Co., 24 Water St., Wakefield, Mass.
Cushman, James F. (D), 182 Glendale Rd., Quincy, Mass.
Edmonds, Bruce A. (D), 55 Coddington St., Quincy, Mass.
Ferris, George M. (D), 103 Liberty St., Lynn, Mass.
Gibbons, Herbert A. (D), Hancock St., N. Reading, Mass.
Gunning, John P. (D), 162 South St., Quincy, Mass.
Stuber, Joseph T. (C), 18 Monument Sq., Charlestown, Mass.

CANADA

McQueen, A. W. F. (C), H. G. Acres & Co., Ltd., Main & Ferry Sts., Niagara Falls, Ont., Canada.
O'Neill, James W. (B), Trane Co. of Canada, Ltd., Mowat & King St., W., Toronto, Ont., Canada.
Sondenaa, Jens V. (D), Royal Norwegian Air Force, 341 Church St., Toronto, Ont., Canada.

CANTON

Eder, M. L. (B), Coast Metals, Inc., 1232 Camden Ave., S. W., Canton, Ohio.

CHICAGO

Ardagh, John C. (B), 3047 N. Kilpatrick Ave., Chicago, Ill.
Boeck, Alfred W., Jr. (D), 1841 N. Mayfield Ave., Chicago, Ill.
Downing, H. M. (C), 323 E. 23rd St., Chicago, Ill.
Foster, Ray (D), 3400 W. Harrison St., Chicago, Ill.
Hess, Edwin A. (B), 914 S. Monitor Ave., Chicago, Ill.
Itkonen, John (D), 1725 Wilson Ave., Chicago, Ill.
Josenhans, John F. (D), 11512 Wallace St., Chicago, Ill.
Keys, Charles V. (C), 635 E. 100th Pl., Chicago, Ill.
Lazar, Jack J. (D), 3055 W. 19th St., Chicago, Ill.
Litz, Frank (D), 1422 School St., Chicago, Ill.
Meisenbach, E. J. (C), 10455 Ave. N., Chicago, Ill.
Patterson, Herbert C. (B), 844 W. Ainslie St., Apt. Q5, Chicago, Ill.
Posey, C. T. (C), 130 N. Parkside, Chicago, Ill.
Sagrillo, Primo (D), 520 N. Monticello, Chicago, Ill.
Spalt, George N. (D), 6111 W. Roosevelt Rd., Cicero, Ill.
Torok, Albert J. (B), 11712 S. Lowe Ave., Chicago, Ill.

CINCINNATI

Croswell, Franklin M. (D), 201 Basset St., Cleves, Ohio.
Kelley, John (C), 3360 Hillside Ave., Riverside, Cincinnati, Ohio.

CLEVELAND

Hardnack, Louis M. (B), Johnston & Jennings Co., 877 Addison Rd., Cleveland, Ohio.
Mackenzie, Mervyn O. (C), 13506 Coit Rd., Cleveland, Ohio.
Profughi, Victor A. (D), 16512 Kipling Ave., Cleveland, Ohio.
Slutes, Brighton P. (B), 1526 Hanna Bldg., Cleveland, Ohio.
Street, Jarvis F. (C), 299 Riverdale Dr., Rocky River, Ohio.
Wartian, Edward S. (C), 17310 Madison Ave., Lakewood, Ohio.

COLORADO

Clayton, William (B), Denver Steel & Iron Wks., Box 1197, Denver, Colo.

DETROIT

Basta, Nicholas (B), 8052 Dwyer St., Detroit, Mich.
Callison, James M. (C), 15490 Monte Vista, Dearborn, Mich.
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National Electric Welding Machines Co., Bay City, Mich.
Progressive Welder Company, Detroit, Mich.
Swift Electric Welder Company, Detroit, Mich.
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Electroloy, Inc., New York, N. Y.
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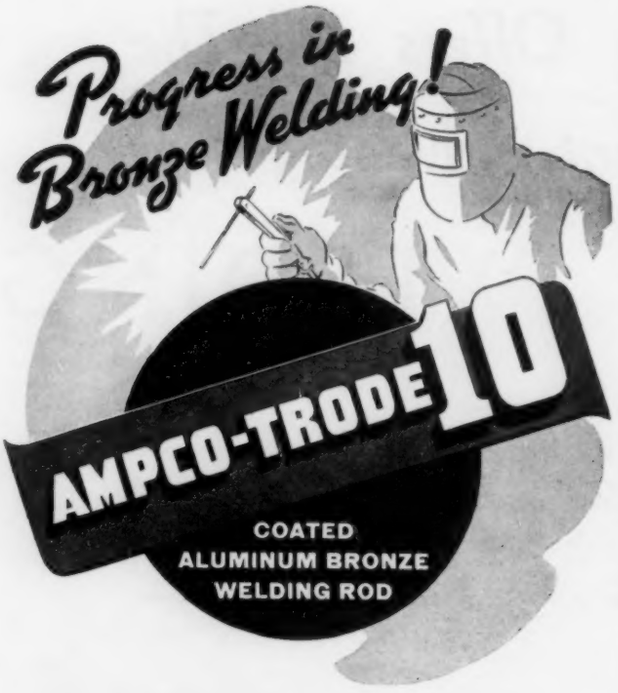

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Complete information regarding Ampco-Trode 10 and other Ampco-Trode Weldrods sent on request. Ask for Ampco-Trode Bulletins.

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(*Continued from page 391*)

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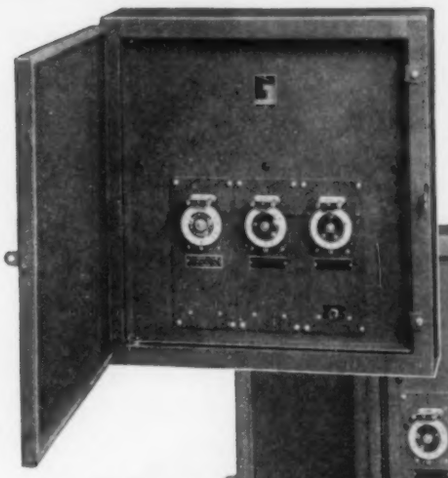
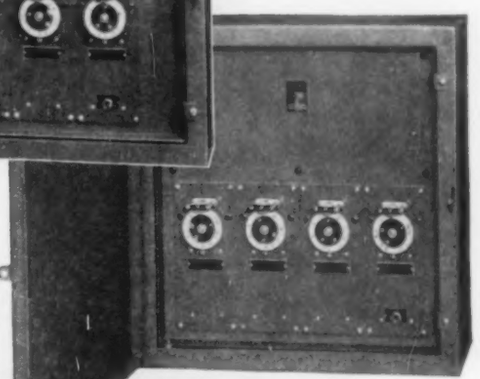
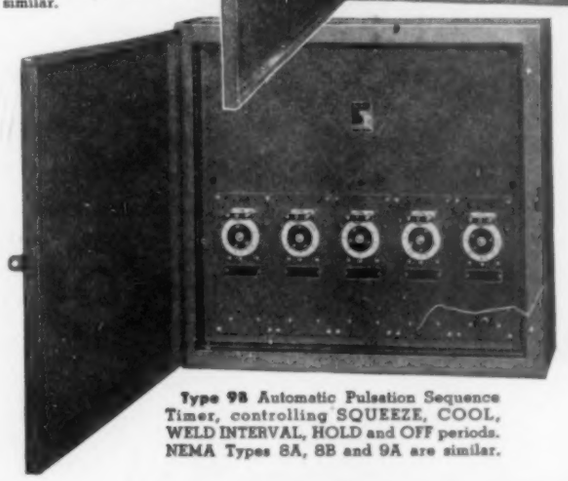


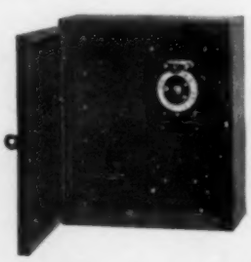
Type 7B Automatic Sequence Timer, controlling SQUEEZE, HOLD and OFF periods. NEMA Types 6A, 6B and 7A are similar.



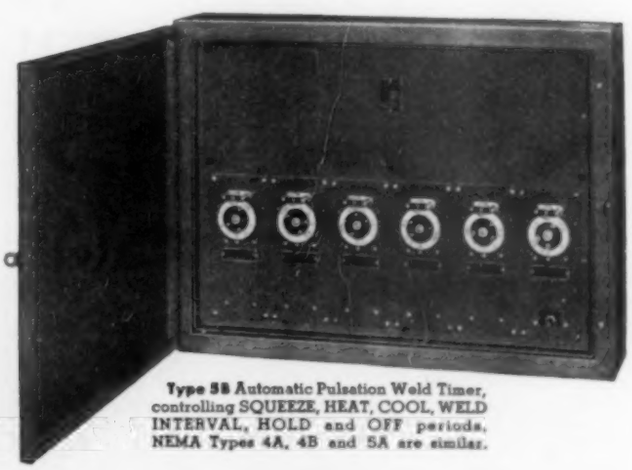
Type 3B Automatic Weld Timer, controlling SQUEEZE, WELD, HOLD and OFF periods. NEMA Types 2A, 2B and 3A are similar.



Type 9B Automatic Pulsation Sequence Timer, controlling SQUEEZE, COOL, WELD INTERVAL, HOLD and OFF periods. NEMA Types 8A, 8B and 9A are similar.



Type 1A Semi-Automatic Timer, controlling only the WELD period. NEMA Type 1B is for pulsation welding.



Type 5B Automatic Pulsation Weld Timer, controlling SQUEEZE, HEAT, COOL, WELD INTERVAL, HOLD and OFF periods. NEMA Types 4A, 4B and 5A are similar.

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Goerke, Arnold R. (D), 95 Columbia Ave., Hartsdale, N. Y.
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Thomas, George J. (C), 63 N. 11th St., Minneapolis, Minn.
Watkins, William (D), 3328 Dupont Ave., S., Minneapolis, Minn.

PEORIA

Baldwin, Harold (C), 220 Bergan St., Peoria, Ill.
Brown, L. G. (D), 124 Pennsylvania, Peoria, Ill.
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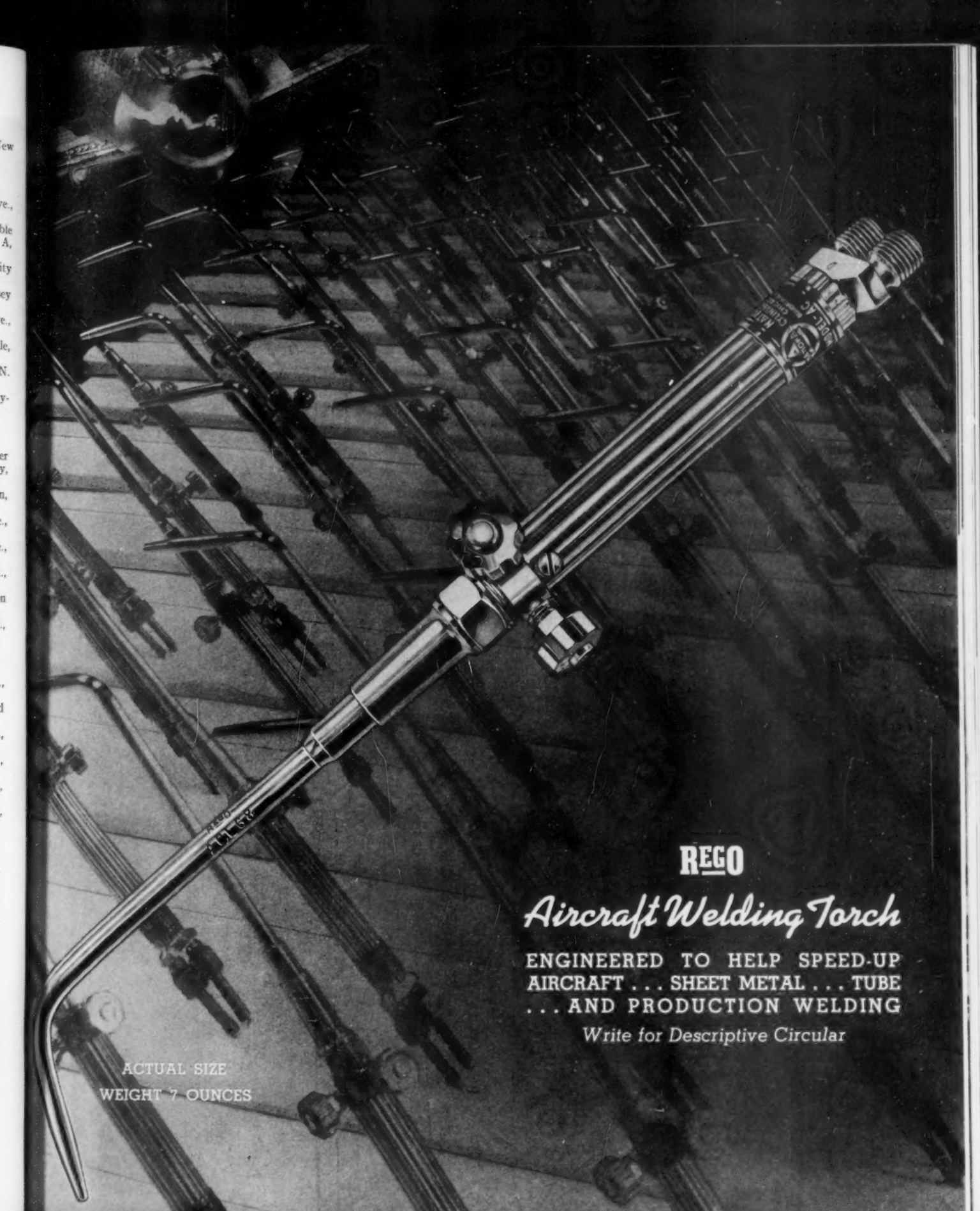

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Goodford, Leon (D), 81 Progressive Ave., Buffalo, N. Y.
Miller, Herbert D. (D), Bell Aircraft Corp., 1050 Elmwood Ave., Dept. 50, Buffalo, N. Y.
Sage, Derreth C. (D), Bolivar, N. Y.
Snyder, M. C. (B), Snyder Mfg. Co., Box 14, Buffalo, N. Y.

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Megla, John (D), 48 Eleanor Ave., Youngstown, Ohio.
Probert, Edward (D), 215 Thornton Ave., Youngstown, Ohio.
Zimmerman, Harold L. (D), R. D. 2, Louisville, Ohio.

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Bauer, Jacob L. (C), Co. L, 7th QM Training Regt., Camp Lee, Va.
Bays, Carson W. (C), 3123 Marne Ave., Norfolk, Va.
Boggess, Robert W. (C), Box 93, Lumberport, W. Va.
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Weatherford, W. W. (C), 7007 N. Olin Ave., Portland, Ore.
York, J. L. (C), The Ingalls Shipbldg. Corp., P. O. Box 149, Pascagoula, Miss.

TECHNICAL ELEMENTS OF WELDING

A second class in the Technical Elements of Welding has been organized to begin with 24 persons on Friday, May 22, 1942.

Course Content: Types of welding; effect of heat on physical properties; design; effect of technique on strength; effect of heat on strength; welding nonferrous metals; visual and mechanical inspection.

Prerequisite: High-school graduation with some practical experience. Drafting and layout experience on welded connections requiring a knowledge of the technical aspects of welding. In-service experience in preparation for positions as welding inspector.

Duration: 8 weeks, 2 nights a week; 12 hours lecture and recitation, 20 hours laboratory; 32 class hours total.

The class will meet on Wednesdays and Fridays, 7:00 to 9:00 P.M.—Engineering, Science and Management Defense Training, the City College of the College of the City of New York.

"SPARKS"

The first issue of *Sparks*, an attractive pictorial quarterly issued by Tube-Turns, Louisville, Ky., is at hand. It is a de luxe 12-page magazine printed in two colors containing interesting and valuable welding information.

STEEL WELDING WIRE OUTPUT ROSE 90%

1941 Production Totaled 453,120,000 pound according to American Iron and Steel Institute

Production of steel welding wire by the steel industry in 1941 totaled approximately 453,120,000 lb., a new high record.

Last year's output was nearly 90% greater than the 238,795,000 lb. of welding wire produced in 1940 and 147% greater than the 183,436,000 lb. made in 1939.

The sharp increase in the manufacture of welding wire last year reflects in part the heavy production of war equipment of all kinds.

From 1932 to 1941, production of welding wire rose 1776%. That gain was nearly four times as large as the increase in steel ingot production since 1932.

For each ton of finished steel produced last year over 7 lb. of welding wire were made, compared with nearly 5 lb. in 1940, and approximately the same figure in 1939.

In 1932, about 2.6 lb. of welding wire were produced for every ton of finished steel products manufactured.

Future Meetings of Other Societies

AMERICAN PHYSICAL SOCIETY, 249th Meeting, June 25–27, 1942, State College, Pa.

AMERICAN SOCIETY FOR TESTING MATERIALS, 45th Annual Meeting, June 22–26, 1942, Atlantic City, N. J.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Semiannual Meeting, June 15–17, 1942, St. Paul, Minn.

AMERICAN WELDING SOCIETY, Annual Meeting, Oct. 11–16, 1942, Cleveland, Ohio.

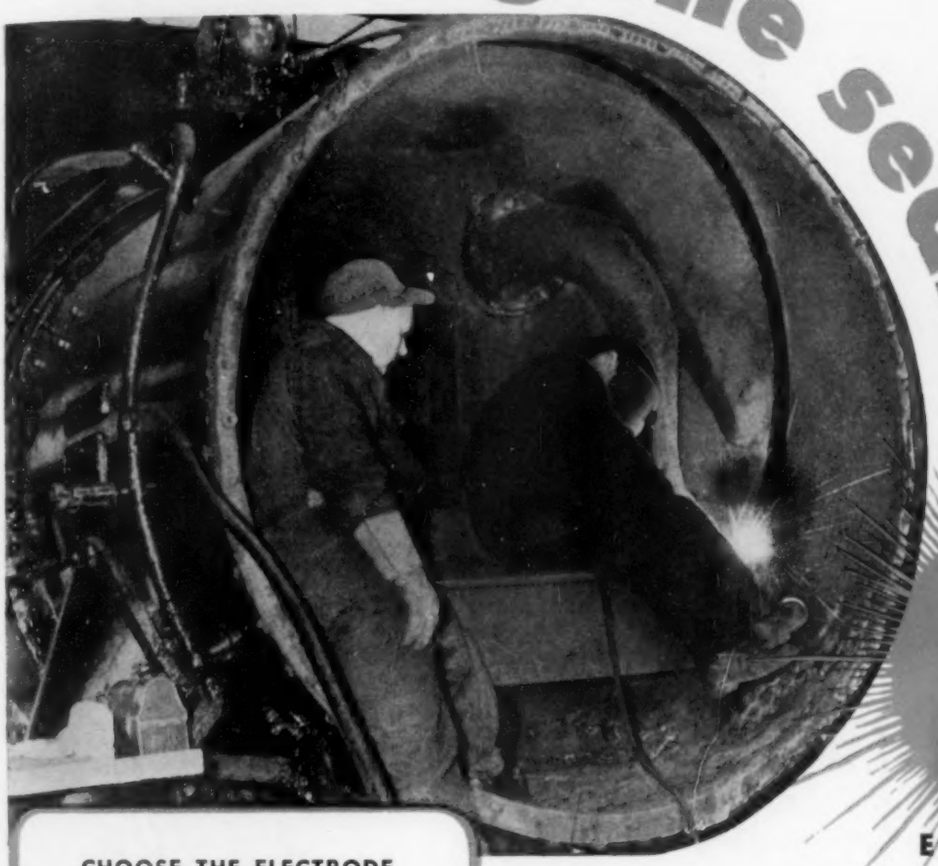
CANADIAN ELECTRICAL ASSOCIATION, Annual Meeting, June 25–26 (tentative), Murray Bay, Que.

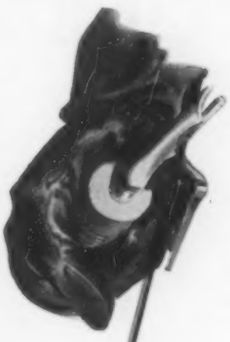
INSTITUTE OF RADIO ENGINEERS, Summer Convention, June 29–July 1, 1942, Cleveland, Ohio.

SOCIETY FOR PROMOTION OF ENGINEERING EDUCATION, Annual Meeting, June 27–29, 1942, New York, N. Y.

FOR UNIFORMLY SOUND WELDS

all along the seam





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CHOOSE THE ELECTRODE FOR THE JOB

FLEXARC FP

Use FP with either a-c or d-c for fillet position and general-purpose high-speed welding on low and medium carbon steels.

FLEXARC DH

Use this "hot" high-speed rod on a-c or d-c for downhand position on heavy horizontal fillets and finished beads.

FLEXARC SW

Use SW for thin sheet metal welding. A general-purpose all position electrode for a-c or d-c current.

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For welding iron castings. Latter type made especially for welds to be machined.

HARDENTOUGH

Four grades to meet all requirements of hard-surfacing parts of machinery.

NICKELCHROM

For welding Stainless Steels

NICKELMANG

For manganese Steel Welding

You'll find it easy to control the metal flow of Westinghouse Flexarc AP Electrodes when making any kind of joint in overhead, vertical, or flat positions on low or medium carbon steels. The performance characteristics of AP rods are balanced with physical properties to speed production of butt, tee, corner or lap joints, and to meet rigid code requirements.

From every position and on every pass, AP fuses solidly, evenly with the parent metal. The special coating protects deposited metal by forming a gaseous arc shield and a light, easily removed slag. Spatter loss is low. Slag volume is at a minimum so that it will not interfere with the welding operation. Beads are flat and smooth.

AP Electrodes are available in diameters ranging from $\frac{3}{32}$" to $\frac{5}{16}$". Try AP yourself and be convinced of its performance. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

J-21192

WESTINGHOUSE

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FLEXARC ELECTRODES

NEW PRODUCTS

The Society assumes no responsibil.ty for the validity of claims in this Section

BOMB FIGHTER

Revolutionary method of fighting incendiary bombs is a new "bomb shovel" invented by two employees of Los Angeles Shipbuilding and Drydock Corporation.

The shovel carries a load of sand in the handle to smother the blazing incendiary. It is made of galvanized sheet metal and weighs only 17 lb. when loaded. It can easily be handled by a housewife in the absence of male members of the family and can be quickly carried to roof or attic.

Sand is automatically released from handle as operator uses hollow side of shovel to smother blazing bomb. Shovel is then turned over and used to scoop up incendiary and remove it to a safe place.

Eliminates need for sand bucket, spade, hoe or shield. Also effective in smothering oil or gasoline fires around the garage.

WAGON

Job shop operators who are searching for salable items to build in their spare time should consider this welded Wonder Wagon built by Doc Fixit's Repair Shop of Mt. Vernon, Ohio. According to Dow Caldwell, Jr., owner of the shop, his shop has already sold over 54 of these farm wagons—netting a very nice profit.

The entire wagon, with its all-welded frame, can be built from used auto parts. Hitch takes any standard 4-in. tongue. Wagon measures 38 in. between stake pockets; telescopes to 10 ft. 6 in. between bolsters; swivel action 2-in. coupling pole; 3-in. channel stakes pockets; 5-in. I-beam axle. For travel over rough terrain, the wagon can be equipped with brakes or a rocking type bolster. Models

Photo, courtesy Hobart Brothers Co.

can be built with ground clearance of 12 or $17\frac{1}{2}$ in.

The Wonder Wagon can be built to sell without tires, for $60—making a nice profit for the job shop owner. Two men can easily pull a three ton load on this wagon over level ground. But its major use is for high speed travel over highways.

ELIMINATING WELD SPATTER

A new product, Acme Quality Industrial Finish Flash-Off No. 99, which is designed to eliminate weld spatters and the time cost of removing them, plus giving a stronger, smoother weld, has just been introduced by the Acme White Lead and Color Works of Detroit, Michigan.

The mechanic simply brushes, sprays or wipes on Industrial Finish Flash-Off along the edges of the metal surfaces to be joined by the weld. Then when the welding is done, metal chips bounce or fall off instead of adhering to areas adjacent to the seam. This eliminates the necessity of grinding or scratching these chips off. The seam is smoother—and it is also stronger because Industrial Finish Flash-Off removes impurities from the weld and, being an excellent conductor of electricity, helps prevent the weld arc from breaking. This is the feature that does much in producing a stronger seam.

WELDING CONTROLLER

Principle.—The "Arctrol" Welding Controller is a foot-operated, variable resistance unit, designed to vary the excitation current of certain D.C. arc welders. In varying the resistance of the excitation circuit, the output voltage and current of the generator are affected. The resistance unit is especially designed to match the saturation curve of the welding machine to which it is applied. The "Arctrol" is designed to regulate the generator output

from full-rated current down to snuffing it out completely.

Features: 1. Crater Elimination.—When ending a weld, a molten puddle remains, which solidifies from the outside to the center. This permits inclusion of gases and slags, which form craters, both hidden and visible.

2. Welding Current Control.—Besides the crater elimination feature, the "Arctrol" provides complete control of the output of the welder. The operator can adjust the current for different welding positions and thicknesses of metal. Any adjustment in the welding current may be easily made by the operator.

Manufactured by Mullenbach Electrical Manufacturing Co., 2300 East 27th St., Los Angeles, Calif.

ARC-WELDED FARM WAGON WILL NOT "WHIP"

Shown in the accompanying illustration is a farm wagon which is guaranteed not to "whip" at any speed.

Built entirely by arc welding, this wagon is the product of the Dye Welding Company of Kingman, Kan. The elimination of whipping is attributed to the strength and rigidity of arc-welded steel.

The photo was sent to The Lincoln Electric Co., Cleveland, Ohio, by E. D. Chilcott, instructor, Ashland High School, Dept. of Vocational Agriculture, Ashland, Kan.

IMPROVING COPPER WITH SILVER

Improving copper by the addition of small percentages of silver has been gaining serious consideration recently. Silver is especially useful in copper which is to be soldered, as the heat applied does not result in undue softening of such an alloy.

SOLVED . . .

. . . WITH A PIECE OF CHALK

Frequently a minor and simple change in weld design may be all that is necessary to overcome a difficulty in welding production.

Murex engineers have frequently worked out such changes on the spot—saving the manufacturer many valuable hours of productive time.

In one instance a new weld design helped a road machinery manufacturer overcome weld failures where cold rolled pins were joined to bearing plates.

Investigation showed that only about 70% penetration was being obtained. The new design called for a 45° bevel of the bearing plate instead of 60° and the machining of a U groove in the pin which previously had been neither beveled nor grooved.

The result was full penetration and elimination of the failures.

The Murex engineering staff is at the service of all companies with war contracts to help them speed up production and improve welding procedure. It is not necessary to be a Murex electrode user to receive this service.

Phone or write our nearest office.

METAL AND THERMIT CORPORATION 120 BROADWAY, NEW YORK, N.Y.

Specialists in welding for nearly 40 years. Manufacturers of Murex Electrodes for arc welding and of Thermit for repair and fabrication of heavy parts.

MUREX

ARC WELDING ELECTRODES

ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

In commutator bars, for example, a small percentage of silver insures that hardness will be maintained. Fractional percentages of silver in photoengravers' plates prevent the softening of cold-rolled copper sheet while it is processed at elevated temperatures. A welding rod containing about 1% silver and a trace of deoxidizer, the remainder being copper, is said to be favored by coppersmiths. Some commercial copper alloys designed for high conductivity contain about 1% of silver and over 95% of copper, though hardening elements such as beryllium, cobalt, cadmium or tin may be added. Silver, of course, is often an important element of brazing alloys in which copper, even up to 85%, is one ingredient, but in these alloys 10% or more of silver is commonly used. High fluidity and good penetration into small clearances, as well as low melting points, are among the advantages gained by the use of silver in such alloys.

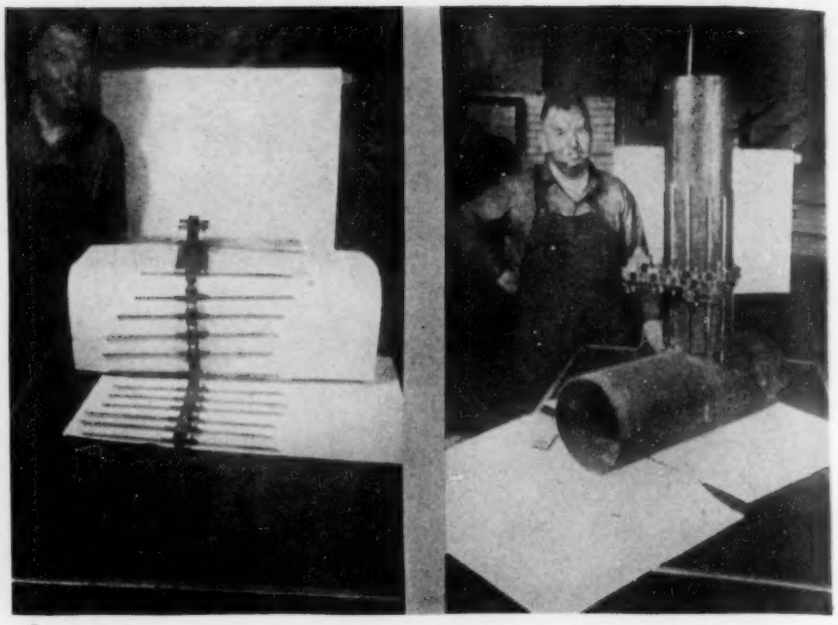
UNIQUE METHOD OF LINING UP PIPE DEVISED BY POWER PLANT WELDER

A simple device for use in lining up pipe preparatory to cutting and fitting is described in a letter to The Lincoln Electric Co., Cleveland, Ohio, from John Bonner, welder in the main power plant of a large utility company, Minneapolis, Minn.

The pictures shown above illustrate the tool. It consists of a drive chain of 1-in. links. The last link of the chain has a piece of $^3/_8$-in. pipe $^3/_4$ in. long welded to it; $^1/_8$-in. standard pipe $^1/_8$ by 3 in. is welded to every second link. Rods, $^1/_4$ in. diam., which will fit perfectly into the $^1/_8$-in. pipe, are sharpened to a side set and hardened. Nuts, $^3/_{16}$ in. in size, are welded to each pipe. Set screws ($^3/_{16}$ in.) in these nuts clamp the rods in the desired position. A $^3/_8$-in. bolt passes through the piece of pipe at the end of chain and holds chain securely in place.

The tool is assembled on the job as follows: A center line is drawn on both the main pipe and the feeder. These center lines are matched as shown in the illustration. The chain, with rods in position, is wrapped around the feeder pipe and fastened in place with the bolt. The rods are pushed down in place so they touch the main pipe and the set screws tightened securely. The sharpened end of the rod is used to scratch the main pipe. After marking, the bolt in the last link of chain is loosened and the tool is moved back on feeder pipe far enough to allow for the cut. Chain is tightened on a straight line on the feeder pipe which is then marked at ends of rods, following the curve made by the rods. Cut both pipes accurately where marked and the two will fit perfectly and may be welded together with a minimum of time, material and effort.

The advantages of the tool will be apparent, as it allows lining up pipes of any size at any angle and cutting them accurately. This tool also reduces waste of material, time and welding rod.



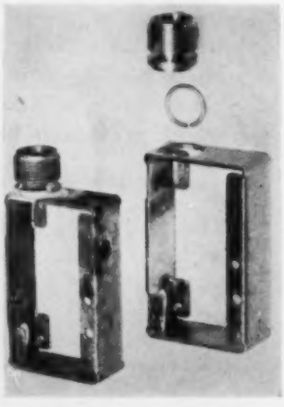
Details of Efficient Device for Use in Lining Up Pipe of Any Size and at Any Angle. Said to Permit Accurate Cutting and Reduces Waste of Material, Time and Welding Electrode. Photos Show John Bonner, the Inventor, with His Device

SILVER BRAZING SPEEDS CONDUIT BOX OUTPUT

Silver brazing alloys are helping materially to speed up our war production in a big majority of metal working plants. One instance is the Micro Switch housing shown in the photograph. The steel stud fitted into the steel box was formerly brazed with a high-melting point base metal alloy; then, after grinding off excess alloy and cleaning, the assembly was cadmium plated.

At present the base metal brazing alloy has been discontinued in favor of a low-temperature silver brazing alloy. Production immediately increased to 3 times the former rate—from 500 per day to 1500 per day. This not only meant faster deliveries to vital war industries, but also permitted an actual reduction in the price of the switch. The brazing procedure is simple and no radical design change was necessary. After the parts are cleaned and fluxed, a ring of brazing alloy is placed between the stud and the box. The assembly is then heated in a gas-fired furnace. At 1175° F. the silver alloy ring melts and flows between the parts, forming a leak-tight joint, stronger than any previous method of joining the two parts.

The manufacturer discovered two other advantages. By low-temperature silver alloy brazing, no grinding is necessary after brazing and the joints remain leak-tight, even when replating is necessary. Formerly, when removing the cadmium, then replating, the joint became porous. Now, joining the parts with the silver brazing alloy, this porosity does not occur. The Micro Switches are all used for war materials, mostly aircraft.



(Right) Easy-Flo Ring Ready for Placing Between Stud and Box. (Left) After Heating to 1175° F. the Ring Has Melted and Penetrated Through Parts. Fast Heating, Low-Brazing Temperature and Elimination of Grinding Increased Production 300% Over Former Method

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LENAPE FORGED PRODUCTS

Complete engineering data on Lenape "Red Man" welding necks, nozzles, elliptical handholes and manholes and forged specialties are contained in Composite Catalog 842 which has just been published by Lenape Hydraulic Pressing & Forging Co.

These products are used extensively by equipment fabricators to the petroleum, ship building, power and chemical industries. Catalog 842 has been prepared as a reference manual to cover all standard and many special applications. Requests for a copy should be sent on company letterhead to Lenape Hydraulic Pressing & Forging Co., P. O. Box 4012, West Chester, Pa.

WELDING HANDBOOK

Available for Distribution July 15

Prepared by 250 of the leading welding experts of the U. S. A.

Worlds's greatest source of authentic, concise, authoritative welding information.

Completely revised and enlarged.

For a short time no restriction will be placed as to the number of copies which may be purchased by an individual Member or Company as the Society feels it essential to make this book available promptly to all workers on War projects.

Sustaining Members and Members of the A. W. S. will receive a free copy of the book; Associate Members and Operating Members will be able to purchase their first copy at $4.00. Extra copies can be purchased by all members from a supply reserved for this purpose at $5.00. Non-members $6.00 in the U. S. A.

1600 PAGES
1942 EDITION

AN ANNOUNCEMENT REGARDING THE WAR PRODUCTION EDITION OF THE NATIONAL METAL EXPOSITION

By W. H. Eisenman, Managing Director

The War Production Edition of the National Metal Exposition will be held in conjunction with the National Metal Congress in Cleveland's Public Auditorium during the week of October 12 to 16, 1942.

Due to governmental and war plant space needs in Detroit, the scheduled event has been moved from that city to Cleveland in order that it might be held this year when so sorely needed.

The 1942 War Production Edition of the National Metal Exposition will be a 100% educational demonstration clinic devoted to increased production, planning, engineering, improvement of materials, job training, conservation, substitution and maintenance. Varied exhibits, catalogues, blueprints, personal conferences and group discussions will also aid in accomplishing the desired end of greater, speedier production.

In sponsoring the War Production Edition of the National Metal Exposition, the Board of Trustees of the American Society for Metals sincerely believes it has an important, constructive role to continue, and that it would be negligent in its duties in this emergency if it did not accept the responsibility and opportunity to aid in securing war production of maximum quantity, maximum quality, maximum progress and with maximum efficiency in the minimum time.

In addition to the A.S.M., three other technical societies will cooperate in the 1942 War Production Edition of the National Metal Exposition as well as the National Metal Congress. They are the AMERICAN WELDING SOCIETY, the Wire Association and the Iron and Steel division and Institute of Metals division of the American Institute of Mining and Metallurgical Engineers. Technical sessions of the four societies are being directed to discussions of ways and means to bring the United Nations an early victory through greater and speedier production.

It is time to pool ideas and information. It is time to cooperate; to consider the other fellow's viewpoint and his problems; to provide full opportunities for the exchange of experiences; for the cross-checking of all progress for the benefit of the war effort as a whole; and to further assist America's metal industry in its major role in the battle of production.

In order to intensify and speed up the mental approach and thus increase production, there must be:

1. A meeting of executives where the frank disclosing of time-saving developments, useful in speeding production, can be made available to all.

2. A meeting of top engineers so that design improvements accomplished by each company may become the common property of all.

3. A meeting of production and process men, where findings dealing with the speediest possible methods of getting war products into quantity production may be placed in the hands of all, and

4. Material, equipment and process manufacturers must see that their products get full opportunity in the hands of the user to do the jobs they were designed to do. These products—their advantageous operation, intelligent use, conservation and maintenance must be explained and demonstrated.

Following the recent Western Hemisphere Foundry Show, a WPB official, after making the rounds of the exhibition halls, said: "the consulting facilities provided by the exhibitors, plus swapping of ideas at the technical meetings, advanced the foundry industry's war program at least six months ahead of what it would have been if forced to rely on normal individual contacts to obtain necessary information."

The value of such a common meeting place as the War Production Edition of the National Metal Exposition is doubly important today. Last October, in Philadelphia, the then timely "National Defense Clinics" presented leaders in technical and military addresses and discussions with regard to ways and means for all-out "Defense" production. Thousands of technical men attended and benefited from the sessions.

BY-LAW AMENDMENTS

At the Board of Directors meeting held on May 7th, the following By-Law Amendments were approved. In accordance with action of the Executive Committee, By-Law Amendments are to be published thirty days before submittal to the voting membership.

Revised:

Article VIII, Section 1 (*m*). A Committee on Awards consisting of *five* individuals each serving for a period of *five* years. The appointment shall be arranged in such a way that one member shall retire *on the adjournment of* each Annual Meeting. The member senior in respect to service shall be Chairman. It shall be the duty of this Committee to make the award and arrange for the presentation of *such medals or other awards as may be authorized by the Board of Directors.*

Revised:

Article VIII, Section 1 (*n*). A Committee on Permanent Funds consisting of five members, each serving for five years, *and the Treasurer of the Society, ex-officio.* The appointments shall be made in such a way that one member shall retire at each Annual Meeting. The member senior in respect to service shall be Chairman.

Funds turned over to this Committee by the Board of Directors shall be in its custody for safe-keeping, investment or reinventment. All acts of the Committee shall require the favorable vote of at least four members of the Committee.

No disbursement shall be made from these funds except upon a favorable vote of at least two-thirds of those present at a meeting of the Board of Directors called for that purpose at which a quorum is present.

A notice of the meeting shall be sent to each member of the Board of Directors at least two weeks before the date set for the meeting. The notice shall set forth the reasons why the disbursement is proposed.

The Committee shall keep full and accurate accounts of receipts and disbursements in books belonging to the SOCIETY, and shall render a financial statement to the Board of Directors annually, or oftener if requested.

Addition:

Article VI, Section 5. Duties of District Vice-Presidents. The District Vice-President shall be the official representative of the Society in his District. He shall be responsible for the general promotion of the Society in his district and shall act as contact man between Headquarters and his District. He shall perform such other duties as specified in the By-Laws.

Renumber present Sections "5 to 7" to "6 to 8."

LOUISIANA SECTION REORGANIZED

The Louisiana Section of the AMERICAN WELDING SOCIETY held its reorganization meeting at the New Orleans Athletic Club on the night of May 4th. The meeting was an outstanding success with an attendance of 70. In the absence of Mr. G. O. Huet, Mr. Mace H. Bell, Temporary Vice-Chairman, acted as Chairman. Mr. F. T Llewellyn, Past-President of the SOCIETY, who has retired and lives in Baton Rouge, attended and delivered an address covering the activities of the SOCIETY. Mr. E. B. Williams, Vice-President, Delta Shipbuilding Company, Inc., presented an address on the application of welding in Liberty Ship Construction at the Delta Shipbuilding Company. Mr. Mace H. Bell, District Engineer of the American Institute of Steel Construction, followed with an address on the aims and objectives of the AMERICAN WELDING SOCIETY and the benefits that can be derived from membership in the Louisiana Section.

Mr. Bell pointed out that in the past year New Orleans has witnessed the influx of a number of new industries devoted to production of materials of war. In addition, existing industries have received a great impetus by the increasing demand for more and more production. In the months ahead this tempo will be increased.

In many of these industries, welding plays a major role. Development in the art of welding metals has advanced to the point where it is used widely as the speediest, most economical method of joining metals in ships, in structures, in tanks and in hundreds of other applications.

Mr. Bell pointed out that everyone engaged in the various branches of the metal working industry must of necessity keep up to date on welding, and particularly so because of the rapid expansion of its application in new fields and because of the many new developments that are taking place. Membership in the A.W.S. in a variety of ways offers the best possibility of doing this.

SECTION ACTIVITIES

BOSTON

At the annual meeting held in April the following officers were elected to serve for the year 1942–43: *Chairman*, P. L. F. Feyling, Whitehead Metal Products Co., Cambridge; *Vice-Chairman*, F. W. Davis, E. B. Badger & Sons Co., Boston; *Secretary-Treasurer*, P. N. Rugg, Boston Edison Co., Boston; *Trustee*, H. G. Austin, Lukenweld, Inc., Boston. *Directors* (for two years): George Richardson, General Electric Co., Lynn; C. A. Rober, Bethlehem Steel Co., Shipbuilding Div., Quincy; W. A. Ovaska, Air Reduction Sales Co., Boston.

CHICAGO

At the April 17th meeting of the Chicago Section, Mr. Louis J. Larson, Consulting Welding Engineer of Milwaukee, Wis., presented an interesting illustrated talk on the "Metal Transfer in the Metallic Arc" before a group of approximately 200 people. Mr. Larson reviewed the theories and investigations of numerous researches on this subject and also related his own experiments which indicated that gases in the steel were responsible for the metal transfer from the electrode to the base material. A lively and lengthy discussion followed.

A sound motion picture entitled "Oil for Aladdin's Lamp" was shown at the start of the meeting through the courtesy of Shell Oil Co. This is a very recent production and shows vividly all the products derived from petroleum.

A special meeting was arranged for Wednesday, April 29th, at the Chicago Lighting Institute for the members and their ladies. Mr. Carl W. Zersen, Manager of the Institute, gave a demonstration and lecture on the subject "From Flame to Fluorescence in Lighting." A dinner at the Electric Club preceded the meeting.

CLEVELAND

An enthusiastic attendance of 400 welding people, including executives and production officials, attended the Spring Conference of the Cleveland Section, May 8th, at Hotel Statler.

A total of five technical papers were presented. The afternoon session, beginning at 2 o'clock, included: "Unionmelt Welding," by W. B. Browning, The Linde Air Products Co., Chicago, Ill.; "Welding of Aluminum and Its Alloys," by George Hoglund, Aluminum Co. of America, Pittsburgh, Pa.; and "Resistance Welding Helps War Effort," by Ben Wise, Federal Machine & Welder Co., Warren, Ohio.

The dinner, which was held at 6:30, was followed by a review entitled, "Memories of Early Welding Days," by C. J. Holslag, Electric Arc, Inc., Newark, N. J.

The two papers of the evening session which began at 8 o'clock, included: "Smith-Dolan System of Induction Preheating and Stress Relieving," by Mr. Holslag; and "Elements of Welded Design," by Leon C. Bibber, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

The committee in charge of arrangements included J. F. Maine, chairman of the Cleveland Section, and J. R. Kriz, program chairman of the conference.

Announcement was made of the officers for the coming year. They are: J. R. Kriz, James Herron Co., *chairman;* C. T. Elder, Cleveland Electric Illuminating Co., *vice-chairman;* and J. Leslie Pfeil, Universal Power Corporation, *secretary-treasurer.*

COLUMBUS

Colonel G. F. Jenks, President of the AMERICAN WELDING SOCIETY, was the guest speaker at the May 8th meeting of the Columbus Section. Colonel Jenks spoke on the position of the AMERICAN WELDING SOCIETY in the present emergency.

DETROIT

The second Annual Dinner Dance tendered to the past-chairmen, their wives and families, by the Detroit Section members, was held at the Detroit Leland Hotel the evening of May 1st. More than 140 persons were present.

Following a superb dinner, Mr. O. L. Smith, Acting Chairman of the Section and Presiding Officer at the dinner, read telegrams from Secretary Sieger, Chairman Brendle and Past-Chairman Tebben, expressing their deep regret at their inability to attend the dinner. Mr. Smith took occasion to pay special tribute to Mr. Sieger for his unflagging zeal in promoting the Section's welfare and to Mr. Brendle for his energetic leadership as Chairman. (Mr. Brendle was obliged to resign as Chairman before his term had expired, due to his transfer to Florida.)

The appreciation of the Section was expressed to Mr. Earl Foss, Second Vice-Chairman, who was responsible for planning and arranging the dinner, and whose activity on membership promotion has been productive of a considerable increase in the Section enrolment; likewise, to Mr. Neitzell, whose fine membership work included the enrolment of a new Sustaining Member.

Next, Mr. Smith presented Mr. Vaughn Reid, Mr. D. H. Corey and Mr. W. M. Hays, Past-Chairmen of the Section. He turned over to Mr. Hays the Past-Chairman's Pin for Mr. Brendle with the request that it be passed on to him.

The National Secretary was presented to the audience, and after expressing delight at being present, congratulated the Section officers and membership on their splendid accomplishments, both on membership and technical meetings.

During the dinner, the group was entertained by a boys' orchestra and immediately following the dinner by "New Horizons of Science," an illustrated lecture procured through the courtesy of General Electric Company. The remainder of the evening was given over to dancing, which was enjoyed by all present.

This annual affair of the Detroit Section is always outstanding not only as a social gathering, but also as an evidence of the good will, cordiality and enthusiasm existing in that group.

The inaugural meeting of the new administration has been called for June 5th at the Engineering Section, Horace H. Rackham Educational Memorial, when committees will be appointed and plans laid for next season's meetings.

LOS ANGELES

The Los Angeles Section held its monthly meeting on April 16, 1942, at Scully's Cafe. There were 78 members present.

This meeting was devoted exclusively to Resistance Welding, and we had the assistance of several specialists who explained the use of chart diagrams and blow-up pictures.

Mr. T. R. Lawson, Electronic Control Engineer for Westinghouse Electric, was the main speaker and his subject, "Fundamentals of Electronic Controls for Resistance Welding" was well presented. It was told very simply, and the essential facts were boiled down to a layman's understanding.

Mr. Wetzel of the Thermador Electric Company explained the operation of automatic equipment built by the Progressive Electric Company. Most of the pictures covered hydromatic resistance welders used in the automotive industry.

Mr. H. B. Axtel of the Moore Machinery Company answered questions from the floor during the open forum session.

The June meeting will be held on the 18th. The following subjects will be discussed: Welded Dirt Removing Equipment; Railroad Welding; Aviation Inspection.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held on April 24th. Lieutenant Leo O'Brien of the Procurement Office, U. S. Naval Reserve gave an after-dinner talk. Mr. A. F. Plant, Regional Vice-President, The Austin Company, gave the welding address on "Welding in the Design and Construction of Industrial Plants." Mr. Plant's talk was illustrated with slides showing the increasing use of welding in factory building over the past thirteen years, and motion pictures showing the construction of welded rigid frame structures.

NEW YORK

The New York Section cooperated with other engineering societies in presenting a program on the Engineering Aspects of the National Industrial Scrap Salvage, which was held in the Engineering Societies Building, New York, on Tuesday, April 28th.

The New York Section of the AMERICAN WELDING SOCIETY held its Annual Meeting on Tuesday May 12, 1942, at the Engineering Societies Building. Chairman for the evening was W. A. Howard of Socony Vacuum Oil Co., Inc., Brooklyn, N. Y.

The speaker was A. N. Kugler, Mechanical Engineer, Air Reduction Sales Co., New York, who spoke on the subject "Oxyacetylene Welding in War Production." Mr. Kugler reviewed a number of oxyacetylene procedures which may be employed under current Government specifications. Among the topics covered were: oxyacetylene welding of piping for ships; oxyacetylene welding in the manufacture of gasoline cans; oxyacetylene welding in aircraft construction; oxyacetylene welding and cutting in the fabrication of jigs and fixtures; and low-temperature brazing in the repair of machine tools. Mr. Kugler accompanied his interesting talk with numerous lantern slides.

Following Mr. Kugler's talk, an all-color, sound moton picture "Fundamentals of Air Welding" was presented through the courtesy of The General Electric Company. This picture showed what actually goes on inside the arc, with details of arc and crater clearly revealed. Ingenious animated cartoons and actual welding shots added to the interest of the picture.

The evening opened with a half-hour question-and-answer period conducted by H. R. Morrison, The Linde Air Products Company, New York. This was followed by a short business session at which the election of officers for the 1942–43 season was announced. Officers for next season are: *Chairman*, W. A. Howard, Socony Vacuum Oil Co., Inc.; *1st Vice-Chairman*, G. Schneider, Acetylene & Welding Equipment Company; *2nd Vice-Chairman*, G. V. Slottman, Air Reduction Sales Co.; *Secretary-Treasurer*, George Sykes Union Carbide Co.; *Executive Committee Members for 3 Years*, E. A. Kerbey, Midwest Piping & Supply Co., Inc.; J. L. Wilson, American Bureau of Shipping; J. B. Tinnon, Metal & Thermit Corp.; and H. W. Northcutt, Bethlehem Steel Co., Shipbuilding Division.

NORTHERN NEW JERSEY

The May meeting of this section was held on the 19th in the Essex House, Newark. Mr. George T. Horton, President, Chicago Bridge and Iron Co., spoke on "Welding—Past, Present and Future."

A movie "The Inside of Arc Welding" was presented through the courtesy of the General Electric Company.

This was the last meeting of the spring season. Regular meetings will be resumed in September.

OKLAHOMA CITY

A large number of members and guests attended the Section Meeting of May 7th. The principal speaker for the evening was Mr. A. N. Kugler of the Applied Engineering Department, Air Reduction Sales Company. Mr. Kugler's subject was "The Design of Welding Jigs and Fixtures." His subject was of considerable interest and importance to the Local Section, especially at this time. Mr. Kugler also presented a picture in technicolor showing the fabrication and erection of an all-welded mill-type building.

Members of the Local Section are appreciative of a recent letter from John Lang, who formerly was associated with the Local Section, and is now connected with the New York Shipbuilding Corporation. Mr. Lang's letter was read by Joe Mideke at a recent meeting.

No meetings will be held during the months of July, August and September. Anyone wishing to contact the Local Section during the summer may do so through the National Office.

PHILADELPHIA

The speaker at our April 20th meeting held at the Engineers' Club, was Mr. A. Amerikian, Design Engineer, U. S. Navy Department, Bureau of Yards and Docks, who spoke on "Welding of Buildings." It was one of this season's most interesting talks. The speaker left no doubt in the minds of his audience that building design for Navy shore establishments was subject to the same limitations as to available materials as similarly rated private projects. Mr. Amerikian and his associates are meeting this situation in a large measure and with considerable ingenuity based upon experience gained in the pre-defense and pre-war periods with welded construction specifically designed for welding. The pre-war method had been to try to approach each job even when it was an extension of an existing building, as a new design problem with certain space, function and load conditions to be met. This experience in elimination of "handbook" design methods of approach, which among other things involved overcoming the usual structural engineers' desire to stay away from "indeterminate" structures, is now paying dividends.

Slides of drawings and photographs illustrated structures for usual, as well as for specialized use. Aircraft hangers and caisson gates were interesting examples of the latter. Shop and storage buildings were similar in function but obviously superior in design to the majority found in industry. The Mess Hall at the Naval Academy at Annapolis is an outstanding example of pleasing appearance obtained by good functional design through the proper use of welding.

At the May 18th meeting the speakers were Mr. H. Irrgang, Superintendent of the W. K. Mitchell Company and Mr. H. O. Klinke, Welding Engineer, U. S. Navy Yard, who discussed "The Welding of High Pressure Piping" in the general pipe fabrication field as well as in marine construction.

April being the annual meeting of the Section, ballots were tabulated and the following officers unanimously elected for the coming year: *Chairman*, H. W. Pierce, Welding Engineer, New York Shipbuilding Corporation; *Vice-Chairman*, M. W. Brewster, Welding Supervisor, Westinghouse Electric & Mfg. Company; *Treasurer*, R. D. Thomas, President, Arcos Corporation; *Secretary*, K. W. Ostrom, Sales Engineer, Arcos Corporation; *Junior Past-Chairman*, A. J. Raymo, Welding Engineer, Baldwin Locomotive Works. Members of Executive Committee to serve three (3) years: W. W. Barnes, District Manager (retired), Air Reduction Sales Company; R. B. Clements, District Manager, The Linde Air Products Company; O. J. Pearre, Welding Specialist, General Electric Company.

Before passing on the direction of the Section to the new Officers, Mr. A. J. Raymo, *Chairman*, directed a special tribute to the founding members and past-chairmen of the Section. A brief history of the Philadelphia Section since its establishment in 1920 was printed in the April Meeting notice.

In assuming his office of Chairman for the coming year Mr. Pierce expressed the heartfelt gratitude of the Section for Mr. Raymo's able direction of Chapter affairs during the past year, emphasizing in particular the many extra duties imposed by the holding of the National Convention in Philadelphia last October. From the Philadelphia Section viewpoint Mr. Raymo, his Committee Chairmen and their Committee Members carried forward this activity in cooperation with the National Officers in a manner deserving the highest commendation. Mr. Raymo's administration has set a high standard for the incoming officers to meet.

PITTSBURGH

Far-reaching effects of the Defense work in this district were reflected to a great extent by the attendance at the afternoon session of the Fifth Annual Tri-State Convention. Many key men in industrial plants found it impossible to leave their work long enough to be present. However, the evening session drew a capacity attendance as did the informal dinner. Many members and guests who could not be present for the afternoon session did attend the dinner and the evening meeting.

Those who failed to attend in the afternoon, missed hearing the most capable speakers discuss "Welding Fumes" and

"Electric Shock," subjects which have been of considerable interest to the welding fraternity for a long time but until lately have not been widely discussed.

The afternoon session was opened by Chairman A. E. Marble who introduced Mr. Wm. Spraragen, Technical Secretary and Editor from the New York office, who gave a most interesting talk.

Following, Messrs. Gordon C. Harrold, Ph.D., of the Chrysler Corporation, Detroit, Mich., and Dr. C. F. Engel of the Westinghouse Electric & Mfg. Co., presented their talks on the subjects of Fumes and Shock. Both were voted most satisfactory and enlightening and it was to be regretted that so few found it possible to be present to hear such educational presentations.

Due to circumstances beyond his control, Mr. A. G. Bissell, Vice-President, Middle Eastern Division, was unable to be present.

Pressure of other business made it necessary for Chairman A. E. Marble to leave shortly after the opening of the afternoon session and Mr. Frederick H. Dill of the American Bridge Co. took over and carried off the duties in a very satisfactory manner. Opening the evening session Mr. J. B. Carlock of the Jones & Laughlin Steel Corporation and President of the Engineers' Society of Western Pennsylvania, with which Society this was held as a joint meeting, gave a most timely address of welcome, stressing the close cooperation between the various technical societies, the very satisfactory attendances in spite of the demands on all in this district and the great response being made by Welding Engineers in this emergency.

The speaker of the evening, Mr. Roger W. Clark, General Electric Company, Schenectady, N. Y., lived up to all the promises made for him and amply repaid the many present for their attendance by giving a most thorough discussion of the subject "Designers' Problems" bringing out clearly the engineer's responsibility and his relations with the manufacturing groups. Following the discussion the meeting was thrown open for question and at 10:30 P.M. the final meeting for the 1941–42 season came to a most successful ending.

ROCHESTER

The May meeting of the Rochester Section was held on the 7th at Todd Union, University of Rochester, River Campus. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corporation, spoke on the subject "Elements of Welded Joints." This was the second part of a series, the first of which Mr. Bibber gave last year.

ST. LOUIS

Mr. C. J. Holslag, President of Electric Arc, Inc., spoke at the May 7th meeting of the St. Louis Section on the subject "Preheating Welding and Normalizing."

SAN FRANCISCO

The April meeting held on the 17th was a special night for welding students, trainees, welders engaged in shipyard welding, foremen, supervisors, etc. The speakers of the evening were Mr. William L. Reichert, Welding Technician of Bethlehem Shipyard and Mr. Pat Doggett, Welding Foreman of Moore Dry Dock Company, who told the student welders what is expected of them and what they must do to pass the qualifying test as Trainee Welders, and the Trainees, just what they must do to qualify as full fledged Journeymen Welders.

SOUTH TEXAS

The South Texas Section held a meeting on April 20th in Houston, and heard an interesting discussion by Mr. R. F. Arnoldy of The Linde Air Products Company on the use of "Oxyacetylene in the Intensified Industrial Program." Mr. Arnoldy illustrated his points by using lantern slides to show specific cases in which oxyacetylene eliminated "bottle necks" in war production and materially contributed to a speed-up program on assembly lines. Methods of flame cleaning, paint priming and bevel cutting were shown and explained.

WASHINGTON, D. C.

Following is a brief description of the final meeting of the year, held on April 28, 1942, in Washington, D. C., for entry in the JOURNAL under "Section Activities."

The annual meeting of the Washington Section was held on April 28, 1942, beginning with a banquet in the Harrington Hotel, and ending with a Liquid Air Show by Mr. H. R. Salisbury of the Air Reduction Sales Company.

Several old friends and nationally known members of the Society were present, including Bill Spraragen, J. H. Deppeler, R. D. Thomas, Sr., "Whitey" Maurath, Joe Humberstone, Captain C. A. Trexel, Roger W. Clark and Captain W. A. Maddox.

Colonel G. F. Jenks, President of the AMERICAN WELDING SOCIETY, commented briefly on the progress made during the past year. The retiring chairman, Mr. R. B. Swope, introduced the guests. Mr. A. G. Bissell presented the past-chairman's badge to Mr. Swope. Mr. E. Brooker, chairman for the forthcoming year, announced his fellow officers in the Executive Committee, consisting of Mr. W. E. MacKenzie, *vice-chairman*, Mr. H. L. Ingram, *secretary* and Mr. R. F. Wood, *treasurer*.

The Liquid Air Show put on by Mr. Salisbury was both entertaining and instructive. The speaker indicated improvements in incandescent lamps by the use of Argon and rare components of air.

Following the demonstration and discussion, the speaker was called up to answer numerous questions regarding the part of liquid air and its products in the war program.

WESTERN NEW YORK

At the meeting held April 17th officers for the coming year were announced. The following men will carry on the activities of this Section for the 1942–43 period: *Chairman*, John Bos, Jr.; *Vice-Chairman*, Stuart L. Rich; *Treasurer*, Robert Siemer; *Secretary*, Richard S. Lane. *Chairman, Membership Committee*, G. H. Schliecker; *Chairman, Program Committee*, J. W. Dolan; *Chairman, Entertainment Committee*, Wm. Grantham; Board of Directors: James F. Murray, Joseph Cousins, Richard G. Lyall, L. F. Burnham and James K. Dawson.

After dinner and the business meeting a very enjoyable talk was given by Mr. Frank G. Flocke of the International Nickel Co., Inc., New York City, N. Y., on the subject of "Monel, Nickel and Inconel—Their Properties and Fabrication."

WICHITA

A very successful meeting of the Wichita Section of A.W.S. was held on the evening of May 6th. Mr. A. N. Kugler, Mechanical Engineer, Air Reduction Sales Company, New York, N. Y., spoke before an audience of about 75 men, principally from the aircraft industries, on "Jigs and Fixtures for Welding." The talk was illustrated with slides. A Kodachrome film, "Structural Steel Welding" was also shown.

Mr. Kugler spoke with authority on his subject and an interesting discussion of various problems followed the talk. This will be the Section's final meeting this spring.

YOUNGSTOWN

Previous to this meeting, twelve Past Section Officers had met and drawn up a tentative set of By-Laws, and also had nominated officers for the 1942–43 season.

At the April Meeting the following officers who had been nominated, were elected: *Chairman*, T. D. Featheringham, Mgr., Youngstown Welding & Engineering Company, Youngstown; *Vice-Chairman*, Robert Fisher, Air Reduction Sales Company; *Secretary-Treasurer*, H. Ross Strobacker, also of Youngstown Welding & Engineering Company.

An Executive Committee was also elected. This Committee was composed of the newly elected three officers, the retiring three officers and the three preceding officers—making a total of nine.

Following the Election of Officers and the Adoption of the By-Laws, the Section was addressed by Mr. F. E. Le Gates, Chief Inspector of the Hartford Steam Boiler Inspection and Insurance Company, on the subject of "Insurance Companies' Viewpoint on Welding Tests and Inspection."

About 70 members were present.

Sections—CHAIRMEN, SECRETARIES AND REGULAR MEETING DATES

BIRMINGHAM 3rd Fri.
CHAIRMAN—F. E. McATEE, Chicago Bridge & Iron Co., 1564 No. 50th St., Birmingham, Ala.
SECRETARY-TREAS.—W. L. POOLE, Air Reduction Sales Company, 2825 No. 29th Ave., Birmingham, Ala.

BOSTON 2nd Mon.
CHAIRMAN—P. L. P. FEYLING, Whitehead Metal Products Co., Inc., Cambridge, Mass.
SECRETARY—P. N. RUGG, 22 Eastern Ave., Wakefield, Mass.

CANAL ZONE 1st Tues.
CHAIRMAN—PAUL J. CANNELL, P. O. Box 53, Diablo Heights, C. Z.
SECRETARY—R. E. HOLLICK, Box 924, Diablo Heights, Canal Zone

CHATTANOOGA, TENN. 1st Wed.
CHAIRMAN—R. B. BAYSTON, Chattanooga Boiler & Tank Co., Box 110, Chattanooga, Tenn.
SECRETARY—M. R. McLAIN Combustion Engrg. Co., Chattanooga, Tenn.

CHICAGO 3rd Fri.
CHAIRMAN—A. M. UNGER, Pullman-Standard Car Mfg. Co., Chicago, Ill.
SECRETARY—T. E. JEFFERSON, Welding Engineer, 506 S. Wabash Ave., Chicago, Ill.

CINCINNATI, OHIO
CHAIRMAN—ERIC O'HARA, Cincinnati Gas & Electric Co., 4th & Main Sts., Cincinnati, Ohio
SECRETARY—R. L. KIRBY, R. F. D. #1, Box 131, Sharonville, Ohio

CLEVELAND 2nd Wed.
CHAIRMAN—J. R. KRIZ, James Herron Co., 1360 W. 3rd St., Cleveland, Ohio
SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corporation, Cleveland, Ohio

COLORADO 3rd Wed.
CHAIRMAN—J. H. JOHNSON, Johnson Supply Co., Denver, Colo.
SECRETARY-TREAS.—H. W. CREAGER, Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.

COLUMBUS, OHIO 2nd Fri.
CHAIRMAN—F. B. DAHLE, Battelle Memorial Institute, Columbus, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

CONNECTICUT 1st Tues.
CHAIRMAN—H. A. PENNINGTON, A. B. King & Co., 196 Chapel St., New Haven, Conn.
SECRETARY—E. S. ELWOOD, JR., General Electric Co., 1285 Boston Ave., Bridgeport, Conn.

DETROIT 1st Fri.
CHAIRMAN—O. L. SMITH, Weldit Acetylene Co., 638 Bagley Ave., Detroit, Mich.
SECRETARY—G. N. SIEGER, S. M. S. Corp., 1165 Harper Ave., Detroit, Mich.

GEORGIA 1st Fri.
CHAIRMAN—RALEIGH DRENNON, 357 W. Peachtree St. N. E., Atlanta, Ga.
SECRETARY—EDWARD GUILLOTT, 282 Spring St. N. W., Atlanta, Ga.

HAWAII Last Thurs.
CHAIRMAN—GEORGE GLOVER, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H.

INDIANA
CHAIRMAN—WAYNE H. McGLADE, J. D. Adams Mfg. Co., Indianapolis, Ind.
SECRETARY—E. M. LEWIS, Allied Weld-Craft, Inc., 401 West South St., Indianapolis, Ind.

KANSAS CITY, MO. 3rd Mon.
CHAIRMAN—L. R. ST. JOHN, Kansas City Highway Comm., Court House, Kansas City, Kan.
SECRETARY—CARL PETERSON, Welding Equipment Supply Co., 1617 Walnut St., Kansas City, Mo.

LAKE SHORE
CHAIRMAN—FRED HERBST, JR., McMullen & Pitz Construction Co., 923 Commercial St., Manitowoc, Wis.

LOS ANGELES 3rd Thurs.
CHAIRMAN—J. C. GOWING, Hobart Brothers Co., 1007 Santa Fe Ave., Los Angeles, Calif.
SECRETARY—E. O. WILLIAMS, Victor Equipment Co., Los Angeles, Calif.

LOUISIANA 1st Fri.
CHAIRMAN—G. O. HUET, Higgins Industrials, Inc., 1755 St. Charles Ave., New Orleans, La.
SECRETARY—A. E. ABAUNZA, Machine Welding Wks., 1031 Annunciation St., New Orleans, La.

MARYLAND 3rd Fri. except April
CHAIRMAN—A. R. WYNN, 913 North Hill Rd., Baltimore, Md.
SECRETARY—VAN RENSSELAER P. SAXE, 100 W. Monument St., Baltimore, Md.

MILWAUKEE 3rd. Fri.
CHAIRMAN—J. J. CHYLE, A. O. Smith Corp., Milwaukee, Wis.
SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp., Milwaukee, Wis.

NEW YORK 2nd Tues. except when Joint Meeting is held
CHAIRMAN—W. A. HOWARD, Socony Vacuum Oil Co., Inc., 412 Greenpoint Ave., Brooklyn, N. Y.
SECRETARY—GEORGE SYKES, Union Carbide Co., 30 E. 42nd St., N. Y. C.

NORTHWEST 3rd Wed.
CHAIRMAN—J. H. BARRON, Stainless Steel Prod. Co., St. Paul, Minn.
SECRETARY—ALEXIS CASWELL, Manufacturers' Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

NORTHERN NEW JERSEY
CHAIRMAN—T. B. SMITH, Federal Shipbuilding and D. D. Co., Kearny, N. J.
SECRETARY—H. S. CARD, 449 Elmora Ave., Elizabeth, N. J.

NORTHERN N. Y. Last Thurs.
CHAIRMAN—E. F. POTTER, 30 Hazelwood Terrace, Pittsfield, Mass.
SECRETARY—W. W. CHURCHILL, General Electric Co., Schenectady, N. Y.

OKLAHOMA CITY 1st Thurs.
CHAIRMAN—C. C. WILLIS, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
SECRETARY—WM. T. TIFFIN, University of Oklahoma, Norman, Okla.

PEORIA—CENTRAL ILLINOIS
CHAIRMAN—CLIFFORD WIMMER, 1104 Ann St., Peoria, Ill.
SECRETARY—PHIL. SOMMER, 207 N. Bourland Ave., Peoria, Ill.

PHILADELPHIA 3rd Mon.
CHAIRMAN—H. W. PIERCE, New York Shipbuilding Corp., Camden, N. J.
SECRETARY—K. W. OSTROM, 213 Glen Gary Drive, Westgate Hills, Delaware Co., Pa.

PITTSBURGH Middle Wed.
CHAIRMAN—A. E. MARBLE, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
SECRETARY—J. F. MINNOTTE, Minnotte Bros., 1201 House Bldg., Pittsburgh

PUGET SOUND
SECRETARY-TREAS.—JOHN NELSON, Air Reduction Sales Co., 3623 E. Marginal Way, Seattle, Wash.

QUAD CITIES
CHAIRMAN—A. R. GUSTAFSON, 840 Third Ave., Moline, Illinois
SECRETARY—J. W. SHUGARS, Lincoln Elec. Co., Moline, Illinois

ROCHESTER, N. Y. 1st Thurs.
CHAIRMAN—R. L. CATTANACH, American Laundry Mach. Co., 110 Buffalo Rd., Rochester, N. Y.
SECRETARY—PAUL W. JAMES, Lincoln Electric Co., 65 Lancaster St., Rochester, N. Y.

SAN FRANCISCO Last Fri.
CHAIRMAN—FRANK LONGO, Southern Pacific Co., San Francisco, Calif.
SECRETARY—R. E. LABAGH, Victor Equipment Co., 844 Folsom St., San Francisco, Calif.

ST. LOUIS 2nd Fri.
CHAIRMAN—H. H. SHEAFF, Combustion Eng. Co., Heine Boiler Div., St. Louis, Mo.
SECRETARY—M. J. LETICH, Combustion Engrg. Co., Heine Boiler Div., St. Louis, Mo.

SOUTH TEXAS
CHAIRMAN—J. M. HUGHEN, Penn Ship yard, Inc., Beaumont, Texas.
SECRETARY—W. H. GREER, Box 175, Houston, Texas

TULSA, OKLAHOMA
SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla.

WASHINGTON, D. C. 2nd Tues.
CHAIRMAN—B. B. SWOPE, Southern Oxygen Co., Arlington, Va.
SECRETARY—E. BROOKER, 129 South Buchanan St., Arlington, Va.

WESTERN NEW YORK 3rd Fri.
CHAIRMAN—JOHN BOS, JR., 60 West Rd., Eggertsville, N. Y.
SECRETARY—R. S. LANE, Ross Heater & Mfg. Co., 1407 West Ave., Buffalo, N. Y.

WICHITA, KANSAS
CHAIRMAN—W. H. GRIFFITH, % Cardwell Mfg. Co., 801 So. Wichita St., Wichita, Kans.
SECRETARY-TREAS.—R. L. TOWNSEND, 829 S. Madison St., Wichita, Kans.

YORK—CENTRAL PENNA.
CHAIRMAN—W. E. HOLLINGSHEAD, S. Morgan Smith, York Pa.
SECRETARY—C. E. LEWIS KERCHNER, 290 W. Cottage Pl., York, Pa

YOUNGSTOWN (OHIO) 2nd Mon
CHAIRMAN—T. D. FEATHERINGHAM, Youngstown Welding & Eng. Co., Youngstown, Ohio
SECRETARY-TREAS.—H. Ross STROBACKER, Youngstown Weld. & Eng. Co., Youngstown, Ohio